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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine

# RESULTS OF CODLING MOTH INVESTIGATIONS, 1942

## Part I

## Report of the Committee on the Codling Moth

Work Conducted by State Agencies,
Entomological Branch, Canadian
Department of Agriculture
and
Commercial Entomologists

Not for Publication

This pool of information on the results of codling moth research for the season of 1942 is the tenth of a series of similar summaries prepared annually by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, at the request of the Committee on the Codling Moth of the American Association of Economic Entomologists. These data are assembled for the confidential information of workers who are interested in the codling moth problem. The material is not for publication and is therefore not available for quotation or other use without specific permission from the agency which has furnished it.

Mr. R. I. Nel, of the Western Province Fruit Research Station, Stellenbosch, Union of South Africa, expressed a desire to cooperate with the Codling Moth Committee by supplying a summary of the latest data obtained by South African workers. Mr. Nel has been invited to furnish such data and the material, when received, will be included as a supplement to Part I of this pool.

(Not for Publication)

# REPORT OF THE COMMITTEE ON CODLING MOTH FOR 1942

James Marshall, L. F. Steiner, G. M. List, L. G. Gentner,
Edwin Gould, B. F. Driggers, Chairman

By correspondence, your Committee voted unanimously to forego an annual conference of workers interested in codling moth research. It was also voted to continue the annual pool of information and to make a special effort to obtain contributions to the pool from investigators in the United States, Canada and South Africa. The Committee feels that the pool of information has greatly aided research workers in coordinating their efforts and will be of even more value this year, and perhaps for several years, due to lessened opportunity of meeting in groups for discussion. The Bureau of Entomology and Plant Quarantine was requested and has agreed to continue their valuable service in acting as a central agency for collecting the summaries and preparing the pool of information for distribution.

The Committee is of the opinion that the suggestions given in the report on the codling moth for 1941 should be continued with certain revisions and additions. It is believed that the cost of codling moth control has increased out of proportion to the value of the apple crop produced in the principal orchard areas; that there is a need for entomologists interested in the problem to take stock of their investigations and that there is a need for the development of new approaches to the problem. The following suggestions are submitted for consideration in making plans for future work in solving the problem of codling moth control.

1. Abstract all published information on codling moth studies and observations and make copies of the complete abstract available to those persons interested in codling moth research. It is suggested that the Bureau of Entomology and Plant Quarantine take the lead in this undertaking.

2. Continuation of research on substitutes for lead arsenate is needed. The changing of domestic tolerances for lead and arsenic residues has not altered the fact that lead arsenate is inefficient in regions where codling moth injury is severe. Scarcity of the basic materials from which lead arsenate is manufactured during the war period is an added reason for continuing and intensifying the search for substitutes, with special emphasis on nicotine-bentonite.

3. The Committee feels that more attention should be devoted to the study of ways and means of destroying the overwintering larvae and spring pupae; that this is a field of study which has barely been touched upon and if a reasonable proportion of the total research work now being done was devoted to this phase of the problem worth while results might be obtained.

Studies of methods of fortifying lead arsenate as a larvicide should continue with emphasis on the development of chemicals that can be added to lead arsenate sprays to destroy other stages of the insect, particularly the egg and adult.

4. Further attention should be given to the evaluation of strains in certain commercial orchard areas. Studies are also needed to answer the question: Can quick acting stomach poisons or contact insecticides like nicotine-bentonite, phenothiazine, xanthone, etc. lead to the development of resistant or hardier strains?

5. Fundamental studies are needed on physiology with special emphasis on the way insecticides destroy the different stages of the insect or influence the population. In this connection the effect on larvae already inside the apple should not be overlooked. Is the reproductive capacity of the insect or its rate of development affected? Some of the many new materials being tested as insecticides (usually only as ovicides and larvicides) may have entirely unsuspected effects in other ways that might be overlooked.

6. In studies on the habits and behavior of the insect special emphasis should be placed on (1) the relation of the time of moth emergence or moth flights and the time when peaks of larval attacks actually occur, (2) the effects of specific insecticides and adjuvants on the behavior of larvae, adults and natural enemies. Such effects as repellency and attractiveness to adults or larvae might increase or decrease control in limited tests but have little or no effect in large areas. It is also possible that changes in behavior might make the insect more susceptible to other means of control when used in conjunction with a particular insecticide.

7. The reasons for differences in the relative control value of certain insecticides in different regions should be given more attention. It is generally assumed the differences are largely caused by climate, but just how are they responsible? Conflicting reports from different workers may reduce confidence in research unless regional differences are known to exist and their importance emphasized. It is up to the entomologists to show why one insecticide is superior to lead arsenate in one locality but inferior elsewhere.

8. Codling moth research may be improved by the development of more reliable technique in order to make it possible to evaluate properly the many variables with which we must contend. Some workers are limited by time and funds and yet are under extreme pressure for results and can not give much attention to the ideal technique, or even use reliable technique if it requires more work. For this reason the publication of results should give adequate information concerning methods so that others can at least estimate the reliability of the results.

9. The possibilities of biological control should receive more attention. The committee feels that in due time (possibly after the war) some agency should concern itself with the survey and importation of promising parasites and predators of the codling moth. Such surveys should be made in regions other than the probable origin of the codling moth. It is possible that parasites native to South Africa, South America or elsewhere have transferred to the codling moth which could be introduced to advantage in other apple growing regions.

10. The majority of the Committee feels that entomologists have not taken due advantage of the factor of climate, particularly temperature, in the overall problem of codling moth control. It is common knowledge that in nearly every apple growing state or region there are areas or zones of intensity of codling moth attack. The intensity of attack is generally related to the number of broods per season and this in turn is governed to a large extent by the mean annual temperature during the apple growing season. Thus we find different areas where the codling moth is one, two, three or even four brooded and it is in the three and four brooded areas where the greatest difficulty in control is experienced. It is suggested, therefore, that entomologists in collaboration with horticulturists consider the advisability of gradually shifting apple production from the three and four brooded areas to the one and two brooded areas.

11. Entomologists should give more attention to the problem of rotation of apple plantings, either by rotating apples with apples or apples with other fruits, as a factor in the control of codling moth. This would seem to be particularly worthy of study in the three and four brooded areas. It is a general observation that codling moth is more easily controlled on younger and smaller trees. In this connection it would seem worthwhile to study the possibilities of the dwarf and semi-dwarf stocks in areas of severe codling moth attack.

12. There is a need for additional work by entomologists in cooperation with agricultural engineers and spray equipment manufacturers looking toward the development of more efficient machinery for applying sprays. One of the big items in the cost of apple production is the labor and equipment necessary to apply the number of sprays found necessary for adequate control with existing spray combinations.

## ARKANSAS

Dwight Isely, Arkansas Agricultural Experiment Station,
Fayetteville.

The season of 1942 was not more favorable for the codling moth in Arkansas than average. Nevertheless, on account of the shortage of labor spraying for codling moth control was much below standard, and as a rule, codling moth control was very poor. The most important problem of supplies which arose was obtaining repairs for spraying machinery.

The usual orchard experiments in codling moth control were not undertaken. A study of the effect of various materials frequently added to the spray mixture on the initial arsenical deposit was made. These materials included fungicides, safeners, and common stickers and spreaders. None of these were found to increase the initial deposit, and most of them caused an appreciable decrease. The results were based on chemical analyses of arsenical deposit on leaf surface.

## CALIFORNIA

A. D. Borden, California Agricultural Experiment Station,
Berkeley.

### I. Seasonal conditions and abundance

With below normal temperatures in May and part of June the codling moth activity as recorded by bait traps and worm entries was the lowest in the past nine years. Second brood attack was correspondingly low and losses from worminess were at a minimum wherever two good calyx sprays had been applied and were followed by one or two cover sprays.

### III. Results of control experiments

#### A. Control by insecticides

(1) Much improvement has been made in obtaining film-type deposits of standard lead arsenate by use of modified "invert" types of commercial spreaders. Some difficulty was experienced in that these spreaders developed internal combustion in storage in a few instances.

(3) Natural cryolite (3/100 gals.) with summer oil emulsion (1/2 gal./100 gals.) gave better control than nicotine bentonite. The use of light summer oils (1-1 1/2 gals./100 gals.) in the late cover sprays of lead arsenate on pears for the control of codling moth and mites has not proven very satisfactory. This season's field tests with Genicide or Dow DN-111 in the last two cover sprays (June-July) show great promise in meeting this problem.

(4a) Nicotine bentonite (Formula 155-14%) in all cover sprays gave fair control of codling moth on Newtown Pippin apples in a light infestation of the coastal area. One half gallon of light summer oil used as a spreader gave poor wetting and spot deposit.

(4b) Micronized phenothiazine with spreader included (2 lbs./100 gals.) gave excellent control on Newtown Pippin apples in the coastal district when used in the cover sprays following two standard lead arsenates. On Bartlett pears in the same schedule the control was equally good, but it did not control European Red mite and T. bimaculatus infestations.

(4c) Genicide was employed at dosages of 3/4, 1 1/2, 2 and 3 lbs./100 gals. on Newtown apples in the coastal area and on Bartlett pears in the interior valley in all cover sprays. Varying the amounts of Genifilm A and kerosene used with Genicide, the type and amount of deposits could be made satisfactory but there are indications of heavy loss of deposits by weathering. The codling moth control was very good on dosages of 1 1/2 lbs. or over and on Bartlett pears the mites were satisfactorily controlled. A heavy defoliation and russeting of fruit occurred on Newtown Pippin apples following the first cover spray of Genicide (5/18th) when accompanied by three days of high temperature. No injury was noted from subsequent applications.

B. Control by means other than spraying

Bait trap records throughout the middle part of the State show a continued decline in the number of moths taken since 1938.

IV. No difficulty in spray residue removal following a single acid bath either at room temperature or heated to 90° F.

## CONNECTICUT

Philip Garman, Connecticut Agricultural Experiment Station, New Haven

I. Seasonal conditions and status of codling moth infestations during 1942.

The codling moth was not a serious factor in fruit production in Connecticut during 1942. However, it continues to be present and a few growers report increases in abundance over 1941. The serious infestation in Middlefield, reported in 1940, has now subsided and little or no damage was reported from it this year. In Greenwich, near the New York border, infestations increased and some injury was apparent. No experimental work was carried on during the current season with the codling moth as the primary subject of investigation.

III A (1) Investigations of reduced schedules, making use of stickers with special aluminum compounds and oil, have been under way at the Connecticut Station for several years. While still incomplete, we have demonstrated that good control of apple insects, including the rather low codling moth population, can be had with three summer sprays, whereas most growers here are using five to seven. We have not yet been able to secure satisfactory disease control except in favored locations and on varieties not especially subject to scab. Oil in the mix prevents use of sulfurs.

The first combination tried included aluminum aceto-borate, benzoic acid and white summer oil of about 80 sec. visc. Aluminum aceto-borate, if used in sufficient quantity, acts both as a waterproofing agent and safener, probably because of the aluminum hydroxide produced. White oil at the rate of 1/2 gallon per 100 provides the main adhesive element. It is emulsified in the aluminum aceto-borate, benzoic acid mixture, utilizing a small amount of water until the oil is worked in. One and one-half to two pounds of aluminum aceto-borate and 2 to 4 ounces of acid per 100 gallons are needed. So far, excellent safening properties have been noted from use of the mixture and little or no defoliation occurred throughout the season. During 1942 we used aluminum aceto-formate in place of the borate with similar results, but had to add some manganese borate. Laboratory investigations lead us to believe that aluminum hydroxide gel (no benzoic acid needed) may also be used and may be preferable to any of the other aluminum compounds tried so far. However, no field experiments have been made as yet with this material. Aluminum aceto-borate could not be obtained in 1942, but we have at present quotations on aluminum hydroxide gel and aluminum aceto-formate. The following table shows the adhesiveness of some of the mixtures used during 1942.

Analysis Showing Adhesion of 1942 Mixtures
Micrograms $As_2O_3$ per 100. 1 sq. cm. leaf discs.

| | 6/16 | 7/3 | 8/1 | 9/1 | Arsenical fruit residue at harvest grs. per lb. |
|---|---|---|---|---|---|
| 1 Lead arsenate, flotation sulfur, lime<br>5 sprays | 984 | 703 | 669 | 564 | .008 |
| 2 Lead arsenate, oil<br>3 sprays | 2,833 | 2,312 | 1,549 | 1,053 | .014 |
| 3 Lead arsenate, talc, lime, oil<br>3 sprays | 2,264 | 1,613 | 952 | 614 | .010 |
| 4 Lead arsenate, aluminum aceto-formate, oil mixture<br>3 sprays | 3,089 | 2,442 | 1,722 | 1,087 | .013 |

Application No. 1: May 1, 16, 27, June 9, July 7. Lead arsenate 3 pounds to 100 in all sprays.
Applications Nos. 2-4: May 1, 15, June 8, 9. Lead arsenate 3 pounds to 100 in first; 6 pounds to 100 in last two sprays.
All analyses by C. E. Shepard

IV All of our growers were apparently able to obtain spray materials during 1942. There were occasional reports of difficulties in obtaining the quantity desired, but no complaints to the effect that insecticides could not be obtained. All growers here are actively interested in the situation, however, and a few have next year's supply of lead arsenate already on hand. There are practically no reports on equipment, but the situation is beginning to be a little difficult. It may be serious by another year.

## DELAWARE

Paul L. Rice, Delaware Agricultural Experiment Station, Newark.

The research program on codling moth at the Delaware Experiment Station has been terminated so this report will be confined to a consideration of seasonal activity of the pest and the availability of equipment and insecticides during the past year.

Information on the seasonal activities of the codling moth was obtained from cages in which hibernating larvae were confined and from bait traps. The height of emergence of spring-brood moths occurred about May 10 to 12 and the greatest activity in the orchards, as evidenced by bait-trap catches, was during the week from May 13 to 20. The activity of first-brood moths was greatly prolonged and did not reach a very definite peak but trap records indicated that the greatest activity occurred between July 15 and 22. A prolonged period of rain in August discouraged late spray applications and reduced arsenical residues. This resulted in more late-season injury than usual.

No complaints were received from growers on the availability of insecticides for use in codling moth control. Supplies, as a whole, seemed to be adequate. The decreased availability of new equipment did not present a serious problem this year. Several of the new type "Speed" sprayers were purchased and put into use by Delaware growers.

## GEORGIA

C. H. Alden, Fruit Pest and Parasite Laboratory of the Georgia Department of Entomology, Cornelia.

1. Seasonal conditions and codling moth abundance during 1942.

The codling moth spring brood emergence was very heavy in 1942, but the season was cold and many moths died before they had laid their full complement of eggs. As a result, the succeeding broods were light and the infestation at harvest was lighter than 1941. Records were taken daily from 5 bait pots in the experimental orchard and a total of 2,021 moths were caught. The peak number was 549 spring brood moths on April 27th as compared with 361 on May 5th in 1941.

2. Studies of codling moth biology and behavior.

Stung apples were collected for each brood of the codling moth and records were made on larval emergence, pupation, emergence of adults and parasitism. The only larval parasite of any importance was *Ascogaster carpocapsae* and it was less effective than in 1941.

3. Results of control experiments.

Most of the work on codling moth at this station is on biological control. Over 44,000,000 Trichogramma minutum parasites were colonized in commercial apple orchards and egg counts throughout the season showed an average of 46.5% of the codling moth eggs collected were parasitized by this insect.

4. Growers' experience in obtaining insecticides and spray
   equipment in 1942

Both the peach and apple growers in Georgia were able to obtain all the insecticides needed for the control of fruit insects, but they had difficulty and delays in getting the needed parts for the repairs of their spray equipment.

## ILLINOIS

W. P. Flint, Illinois Natural History Survey and Illinois
Agricultural Experiment Station, Urbana

I. Seasonal Conditions.

An extremely heavy carryover of codling moth was experienced during the winter of 1941-42. As a result, there were probably more codling moth larvae in the Illinois apple orchards in late March and early April, 1942, than at any time in the last 10 or 15 years. Conditions were quite favorable to early emergence of adults from the overwintering larvae.

Pupation started in extreme southern Illinois during the week of April 24. By the last of that week, pupation was general in southern and western Illinois. Emergence of adults started in southern Illinois on April 29, and was quite uniform, starting earlier than usual.

Emergence from overwintering larvae was heavy during the first part of May. Eggs were abundant by May 16, with a heavy hatch occurring about May 18-23. The weather then became unfavorable, being cold and wet, so that the infestation was not nearly as heavy as had been expected.

Conditions for second brood were not very favorable, and as a result the infestation in the state was not as heavy as in recent years, and not nearly as heavy as in 1941. Poorly sprayed orchards, however, showed from 50 to 80 per cent of the fruit infested.

The late summer and fall were not particularly favorable, and as a result only a small number of larvae are now in hibernation.

II. No special studies of codling moth biology were carried on during the past year. Light and bait traps were operated at several points in the state and regular records kept, but no special studies were made.

III. The only special control experiments were continuations of tests with commercial fixed nicotines. These were carried on at Quincy and Urbana, Illinois. The results showed that very good control was obtained with a combination of Black Leaf 155 with lead arsenate.

In one large block of about five acres, sprays were given as follows: Calyx spray of lead arsenate 3#, lime 3#; first cover of lead arsenate 3#, lime 3#, followed by 7 applications of Black Leaf 155 in six of which 1/2% of a refined summer oil was used. The variety under test was Red Delicious. A check on September 28 showed 1.9 per cent of the apples stung and 3.8 per cent entered.

Another block of five acres was given a spray consisting of 3# of lead arsenate and 3# of lime, starting in the calyx, followed by four cover sprays of the same materials, in the last two of which 1/2% of summer oil was used. To these last two sprays was added 1-1/2 pounds of Black Leaf 155. The remainder of the season the block received four sprays of summer oil 1/2%, 1-1/2# of Black Leaf 155. A check of this plot on September 29 showed 4.4 per cent stung and 2.7 per cent entered.

A lead arsenate block in the same orchard, on the same varieties, was given a calyx spray of 3# lead arsenate, 3# lime, followed by six sprays of the same material to four of which was added 1/2% of summer oil. On August 29 the plot was given a spray of 1-1/2# of Black Leaf 155 and 1/2% summer oil. A check of this plot on September 29 showed 7 per cent of the apples stung and 3.3 per cent entered

The spray residue at harvest on the plot receiving lead arsenate throughout the season was .127. The residue on the plot receiving 5 lead arsenate sprays, followed by four fixed nicotine sprays was .032 grains of lead per pound. The finish on the fruit in the nicotine plots was excellent.

(A) 1. No special work was carried on with deposit builders. Soybean flour was used in a number of orchards. This material is being generally used by many of our orchardists.

IV. Growers had no difficulty in getting lead arsenate or nicotine sufficient for their needs. Some difficulty was experienced in getting beta naphthol for treating codling moth bands. Spray equipment was extremely hard to secure and in most cases it could not be obtained. The same is true of washing equipment.

One of the principal pieces of work carried on this year in connection with the codling moth studies was a check in 15 growers' orchards on the methods used and the results obtained by the growers themselves. Some of these orchardists used a nicotine schedule. In one of the largest orchards of the state a definite comparison between a lead arsenate and a nicotine schedule was made. These orchards, situated in extreme southern Illinois, showed the following results at harvest time:

| Plots | Orchard | Per cent of fruit<br>Entered | Stung |
|---|---|---|---|
| Lead arsenate | Patterson | 1.3 | 28.5 |
| Nicotine | Patterson | 1.3 | 8.7 |
| Lead arsenate | Lamer | 2.3 | 35.1 |
| Nicotine | Lamer | 2.6 | 11.6 |

## A Study of Control of Codling Moth in Growers' Orchards

Fourteen orchards were studied throughout the season to determine reasons for success and failure. The following factors were found to influence control: 1. Carryover; 2. Orchard sanitation; 3. Kind of materials used; 4. Timing of sprays; 5. Attitude of grower; 6. Type and amount of equipment; 7. Deposit of poison on fruit, dependent on: a. Strength of poison used, b. Number of applications, c. Use of summer oil and stickers, d. Spacing of applications, e. Thoroughness of application, f. Openness of tree, g. Method of spraying tops of trees, h. Number of gallons used per tree, i. Personal supervision of spraying by owner.

## INDIANA

G. Edw. Marshall, Purdue University Agricultural Experiment Station, Orleans

### The 1942 Growing Season

The rainfall during the 1942 season was more than ample till mid-July. After that time there were two periods of dry weather with the most severe one during September. The rainfall during the growing season amounted to 28.63 inches. The codling moth started the season at a distinct disadvantage as the result of wet cool weather but infestations built up in late summer to a point comparable to 1942. This is especially true where a light set of fruit occurred or where the control was poor.

### Materials usedin the Plot Studies

The arsenate used was purchased from the Corona Chemical Company. Tritox products were supplied by the Tritox Chemical Company. This material is made up of calcium arsenate and bentonite. The bentonite contains Santimerse, a wetting agent. This product is usually applied with the bluestone in the absence of lime. The soap used was Grandpa's Pine Tar Soap Chips and the oils were pure white summer oils furnished by the Gulf and Shell Companies. The soybean oil was purchased from the Purina Mills and the bentonite was purchased from the Wyodak Chemical Company. Black Leaf 40 and Black Leaf 155 used were the products of the Tobacco By-Products and Chemical Corp. Black Leaf 40 is a liquid of 40 per cent nicotine and Black Leaf 155 is a powder containing 14 per cent nicotine. The zinc sulphate and aluminum chloride used were obtained from the Mallinckrodt Chemical Works. The lime is the product of the Lehigh Lime Company and the Colloidal "77" is the product of the Colloidal Products Company.

### Plots at the Purdue Entomological Experimental Orchard

All the plots at the Experimental Orchard except one received on April 27 and 28 a calyx spray of 3 pounds of lead arsenate and 3 pounds of lime with 6 pounds of wettable sulphur. A calyx top-off was also applied to all the plots. It was put on April 29 and 30 and contained 3 pounds of lead arsenate and 3 pounds of lime. Plot 2 was the exception and this plot received 5 pounds of Tritox, 2 pounds of bluestone and 2 pounds of bentonite. All amounts given are for 100 gallons of material.

The first six treatments at the Experimental Orchard were applied to single tree plots replicated twice on Winesap, Delicious and Grimes Golden and once on Rome Beauty and Ben Davis. Thus, there were eight single tree replicates involving five varieties.

Treatments 7, 7A and 7B were applied to three single tree replicates only, since these treatments were decided upon late in the season. The quarter-tree system was used in securing infestation data, and included a proportionate number of drops.

The spray program as originally planned for plot 2 included the continuous use of Tritox. However, the injury to both fruit and foliage was so severe after the application of the second cover spray that a continuation of this spray combination was considered inadvisable and a stop-gap treatment was applied for the remainder of the season.

Treatments 1, 3, 4, 7 and 7A as well as 7B were all applied as a study of the possibilities in codling moth control by combinations of lead arsenate and flocculated bentonite with or without nicotine sulphate. Plot 5 is the lead arsenate-lime check plot and may be used for comparison with the other treatments.

The excellent measure of control attained through the use of the plot 4 treatment corroborates the results of similar plot treatments applied in 1941. Other treatments (1 and 3) point to the conclusion that an effective and complete cover of lead-oil-soap or some other such combination must be secured before flocculated bentonite may be expected to control when applied alternately with lead arsenate combinations. Treatment 4 carried residue above the tolerance at harvest time but the residue load could be removed to meet the tolerance by a mild washing treatment. All the plots which received zinc sulphate at the 4th cover spray period had excellent foliage at harvest.

The treatments shown under plots 7, 7A and 7B were applied to learn the effects of two different flocculators for bentonite. It may be seen that 7B is a spray program not unlike 4. In both the control was excellent. Aluminum chloride caused too much foliage injury to use as a flocculator for bentonite. Aluminum sulphate has never given severe foliage injury. Plot 7A was used as a standard by which to compare plot 7.

## Plots at the Elrod Orchard at Mitchell, Indiana

At the Elrod orchard varieties Grimes, Jonathan, Stayman Winesap and Rome Beauty were used in the plot treatments. Each plot replicate contained 10 or more trees and four trees from each replicate were used as checks. From each check tree 200 apples were taken and examined to determine the infestation. The drops under the trees at harvest time were included in the 200 apple samples, in the proper proportion to the picked fruits.

Plot 1 of lead arsenate and lime and plot 2 of nicotine bentonite tank-mix were both included for comparison with the other plot treatments. Plot 3 is a lead-oil-soap schedule with the last two sprays of Black Leaf 155. The Black Leaf 155 was used to prevent too much residue at harvest time.

Plot 4 a lead-oil program with Colloidal "77" a commercial spreader with some sticking qualities shows up very well in control. The foliage was excellent on this plot. Plot 5 is a lead oil schedule with zinc sulphate as a safener. Here the control was fairly good and the foliage was the best of any of the plots.

Table 1. - Spray programs carried on in the plot work at the Elrod orchard in 1942 - Lawrence County, Indiana

| Plot | Cover sprays 1/ | Materials (Amounts per 100 gallons) | Harvest Infestation per 100 fruits Worms | Stings | Affected |
|---|---|---|---|---|---|
| 1 | 1-6 | 3 lb. lead arsenate, 3 lb. lime | 52.2 | 241.7 | 71.2 |
| 2 | 1-5 | 5 lb. bentonite, 1 qt. soybean oil, 1 pt. nicotine | 34.1 | 55.4 | 47.7 |
| | 6 | 2 lb. Black Leaf 155, 2 qt. oil | | | |
| 3 | 1-4 | 4 lb. lead arsenate, 1/2 gal. oil, 1/2 lb. soap | | | |
| | 5 | 1-1/2 lb. Black Leaf 155 | | | |
| | 6 | 2 lb. Black Leaf 155, 2 qt. oil | 32.6 | 91.3 | 52.4 |
| 4 | 1-5 | 4 lb. lead arsenate, 1/4 lb. Colloidal "77", 1/2 gal. oil | | | |
| | 6 | 2 lb. Black Leaf 155, 2 qt. oil | 18.5 | 110.2 | 58.9 |
| 5 | 1-4 | 4 lb. lead arsenate, 1 lb. zinc sulfate, 1/2 gal. oil | | | |
| | 5 | 3 lb. lead arsenate, 3 lb. lime, 1/2 gal. oil, .8 lb. zinc sulfate | | | |
| | 6 | 2 lb. Black Leaf 155, 2 qt. oil | 24.2 | 87.4 | 47.8 |

1/ First cover-sprayed under and outside of trees, applied May 11, 12, 13.
Second cover-sprayed outside of trees only, applied May 20, 21 for north side, May 26, 27 for south side.
Third cover-sprayed under and outside of trees, applied June 8, 10, 12, 13.
Fourth cover - sprayed from tower only, applied July 11, 13, 14.
Fifth cover - sprayed from tower, ground and underside; applied July 28, 29, 30.
Sixth cover - sprayed from tower only, applied Aug. 17, 18, 19, 20.

Table 2. - Spray programs carried on in the plot work at the Purdue University Experimental Orchard in 1942 - Orange County, Indiana.

| | | | Harvest infestation per 100 fruits | | |
|---|---|---|---|---|---|
| Plot | Cover sprays[1] | Materials (Amounts per 100 gallons) | Worms | Stings | Affected |
| 1 | 1,3 | 4 lb. lead arsenate, 1/2 gal. oil, 1/2 lb. soap. | | | |
| | 2 | 5 lb. bentonite, 2-1/2 lb. soap, 1 lb. aluminum sulphate, 1 qt. soybean oil. | | | |
| | 4 | 4 lb. lead arsenate, 1/2 gal. oil, 2/3 lb. soap, 1 lb. zinc sulphate. | | | |
| | 5 | 5 lb. bentonite, 2-1/2 lb. soap, 1 lb. aluminum sulphate, 2 qt. soybean oil. | | | |
| | 6 | 2 lb. Black Leaf 155, 1/2 gal. oil | 34.7 | 120.9 | 49.2 |
| 2 | 1 | 5 lb. Tritox, 2 lb. bluestone, 1 lb. bentonite | | | |
| | 2 | 5 lb. Tritox | | | |
| | 3-6 | 4 lb. lead arsenate, 1/2 lb. soap, 1/2 gal. oil | 17.1 | 117.5 | 60.0 |
| 3 | 1,3,5 | 5 lb. bentonite, 2-1/2 lb. soap, 1 pt. Black Leaf 40, 1 lb. aluminum sulphate, 1 qt. soybean oil | | | |
| | 2 | 3 lb. lead arsenate, 1/2 lb. soap, 1/2 gal. oil | | | |
| | 4 | 4 lb. lead arsenate, 1/2 gal. oil, 2/3 lb. soap, 1 lb. zinc sulphate | | | |
| | 6 | 2 lb. Black Leaf 155, 1/2 gal. oil | 24.1 | 68.5 | 47.2 |
| 4 | 1,2 | 4 lb. lead arsenate, 1/2 lb. soap, 1/2 gal. oil | | | |
| | 3,5 | 5 lb. bentonite, 2-1/2 lb. soap, 1 lb. aluminum sulphate, 1 qt. soybean oil | | | |
| | 4 | 4 lb. lead arsenate, 1/2 gal. oil, 2/3 lb. soap, 1 lb. zinc sulphate | | | |
| | 6 | 2 lb. Black Leaf 155, 1/2 gal. oil | 13.0 | 59.9 | 37.6 |
| 5 | 1 | 4 lb. lead arsenate, 4 lb. lime | | | |
| | 2-6 | 3 lb. lead arsenate, 3 lb. lime | 23.4 | 120.2 | 53.2 |
| 6 | 1-3 | 4 lb. lead arsenate, 1/2 lb. soap, 1/2 gal. oil | | | |
| | 4 | 4 lb. lead arsenate, 1/2 gal. oil, 2/3 lb. soap, 1 lb. zinc sulphate | | | |
| | 5 | 5 lb. bentonite, 2-1/2 lb. soap, 1 lb. aluminum sulphate, 1 qt. soybean oil | | | |
| | 6 | 2 lb. Black Leaf 155, 1/2 gal. oil | 25.4 | 85.8 | 55.2 |

Table 2. - continued

| Plot | Cover sprays[1] | Materials (Amounts per 100 gallons) | Harvest infestation per 100 fruits | | |
|---|---|---|---|---|---|
| | | | Worms | Stings | Affected |
| 7 | 1 | 5 lb. bentonite, 1 pt. Black Leaf 40, 1 qt. soybean oil | | | |
| | 2,3,5,6. | 8 lb. aluminum chloride, 3 lb. Black Leaf 155, 1 qt. soybean oil | | | |
| | 4 | 3 lb. Black Leaf 155 | 30.5 | 34.4 | 37.6 |
| 7A | 1 | 5 lb. bentonite, 1 pt. Black Leaf 40, 1 qt. soybean oil | | | |
| | 2 | 8 lb. aluminum chloride, 3 lb. Black Leaf 155, 1 qt. soybean oil | | | |
| | 3-6 | 3 lb. Black Leaf 155 | 50.6 | 51.7 | 54.0 |
| 7B | 1 | 4 lb. lead arsenate, 1/4 lb. Colloidal "77", 1/2 gal.oil | | | |
| | 2,3 | 4 lb. lead arsenate, 1/2 lb. soap, 1/2 gal. oil | | | |
| | 4 | 4 lb. lead arsenate, 1/2 lb. soap, 1/2 gal. oil, 1 lb. zinc sulphate | | | |
| | 5,6 | 8 lb. aluminum sulphate, 3 lb. Black Leaf 155, 1 qt. soybean oil | 10.1 | 32.7 | 27.8 |

[1] First cover applied May 17, 18, 19.
Second cover " June 2.
Third cover " June 17, 19, 20.
Fourth cover top-off applied July 2, 3; fourth cover applied July 7, 8.
Fifth cover applied July 21, 22, 23.
Sixth cover applied Aug. 11, 12, 13, 14.

## KANSAS

Ralph L. Parker and Paul G. Lamerson, Kansas Agricultural Experiment Station, Manhattan.

### Introduction

Zinc sulfate in combination with lead arsenate and summer oil emulsion was tested again during the season of 1942 for control of the codling moth and as a safener for lead arsenate when used on Jonathan foliage. Summer oil emulsion was used in a series of tests from the second through the fifth cover sprays to determine the effect upon arsenic residue removal at the end of the season. Lead arsenate alone without any safener was used on one series of tree replicates and two series of replicates were devoted to testing a lead arsenate-bentonite combination and "Tritox", a tricalcium arsenate-bentonite mixture. The tests were conducted in the experimental orchard of the Northeast Kansas Experiment Fields, Doniphan County, Blair, Kansas.

### Methods and Procedure

Two-tree replicates of the Jonathan variety were used for each dosage and material to be tested. The replicates of each treatment and dosage were randomized throughout 5 rows of trees containing 10 trees to the row.

Dropped apples were picked up at intervals during the summer, counted and scored for worms and stings. The preharvest dropped apples to the number of 250 per tree were counted and scored for worms and stings from September 4 to 7. A storm the night of September 14 made necessary the picking up and scoring of 250 fruits per tree for worms and stings. This was designated as the harvest count, since following this storm many trees of the plot concerned in the tests had fewer than 250 fruits remaining on the trees.

The oil was omitted from the second to the fifth cover sprays in a series of lead arsenate-zinc sulfate-summer oil plots to determine whether residue difficulties of the 1941 season would be encountered again at the end of the 1942 season. In making the arsenic residue analyses the apples were washed 2 1/2 minutes, stirring continuously in a 3 percent (by volume) of concentrated hydrochloric acid in tap water. The temperature of the wash solution was raised to 35° C. before the apples were added.

Bordeaux mixture 1-2-50 was added to the sixth cover spray on July 23, to help control Jonathan leafspot, also called frogeye or blackrot.

### Seasonal Conditions and Codling Moth Abundance First Brood.

The first moths from the overwintering generation of larvae were caught in bait traps on May 13. Cool nights and unseasonably cool days tended to reduce the number taken in the bait traps during the first part of the moth emergence season. The first worm entries from first brood larvae were noted on May 26. This was seven days later than for the season of 1941. The heaviest hatch of worms occurred from June 13 to 15. By June 1, the catches of overwintering brood moths began to diminish. The interval from June 15 to 22 was one of unseasonably cool nights and small bait trap catches. There was a pronounced depression in moth population between the first and second broods. From June 22 to July 15, variable weather conditions resulted in a prolonged and slow emergence of the first brood moths.

## Second Brood.

On July 15, bait trap catches indicated that the first brood moths were emerging. On July 17, emergence of first brood moths was confirmed by moths appearing in the emergence cage. This emergence date was fully two weeks later than for the season of 1941. Cool nights held down the catches of moths in bait traps from July 20 to 25. The heaviest hatch of worms of the second brood occurred during the interval from August 10 to September 10. Injury to fruit by the first half of the second brood was light. Injury to fruit by the last part of the second brood was extremely heavy, the heaviest damage of the season.

## Third Brood.

As far as it was possible to determine, there was no third brood of worms. Worms found late in the season probably were from a prolonged second brood moth emergence which had been delayed fully two weeks later than normal.

## Seasonal Damage

The codling moth season of 1942 was characterized by a light, easily controlled first brood, the activity of which was held down by unfavorable weather conditions.

The beginning of the second brood was delayed two weeks later than for the season of 1941. Since the last half of this brood found weather conditions favorable for its development, there resulted from August 20 to September 10, the heaviest worm damage of the season.

Due to plentiful rains, cool nights and irregular warm weather conditions, bait trap catches, in terms of numbers of moths caught, were not a reliable index of damage to be expected during the season of 1942.

The last 3 sprays of the season of 1942 were the more important sprays for protecting the crop from the heavy hatch of late worms. Severe damage to fruit can result from late worms even when the control of first brood worms appears to have been highly successful.

## Materials and Dosages

The insecticide combinations used are indicated in table I.

TABLE I. Kinds and quantities of insecticide used in the control tests in pounds per 100 gallons of spray mixture.

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TREATMENT:

1. Tritox - (calcium arsenate plus bentonite), 4 pounds.
2. Lead arsenate, 4 pounds plus 2 oz. Wyoming bentonite.
3. Lead arsenate, 4 pounds (all cover sprays, 9).
4. Lead arsenate, 4 pounds plus Superla summer oil emulsion 1 qt. plus zinc sulfate ($ZnSO_4$), 1/4 pound through second cover spray. Oil left out of third through ninth cover sprays.
5. Lead arsenate, 4 pounds plus Superla summer oil emulsion 1 qt. plus zinc. sulfate ($ZnSO_4$), 1/4 pound through third cover spray. Oil left out of fourth through ninth cover sprays.
6. Lead arsenate, 4 pounds plus Superla summer oil emulsion 1 qt. plus zinc sulfate ($ZnSO_4$), 1/4 pound through fourth cover spray. Oil left out of fifth through ninth cover sprays.
7. Lead arsenate, 4 pounds plus Superla summer oil emulsion 1 qt. plus zinc sulfate ($ZnSO_4$), 1/4 pound through fifth cover spray. Oil left out of sixth through ninth cover sprays.

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Information in regard to spray dates was gathered from two sets of codling moth bait traps, or a total of 20 traps. One set of 10 traps was located at the Blair experiment orchard, Blair, Kansas, and the other set at the Frank Lehman orchard, Wathena, Kansas. This pertinent information was furnished to growers by the Doniphan County Farm Bureau, Troy, Kansas. Spray dates for the 1942 season were as follows: Calyx, May 7; first cover, May 19; second cover, May 29; third cover, June 6; fourth cover, June 22; fifth cover, July 15; sixth cover, July 23; seventh cover, August 5; eighth cover, August 19; and ninth cover, August 31.

## Results

In recording the data of injured fruits, multiple stings or worms in any one fruit were not considered. When a fruit had stings and worms present, such fruit was placed in the category "wormy".

The arsenical burn of foliage was determined by comparative observation of leaf color or injury and the retention of foliage at the end of the growing season. The plot sprayed with Tritox (tricalcium arsenate-bentonite) had the most severe or 75 percent arsenical burn of foliage. The lead arsenate alone plot had 50 percent foliage injury through the season. The plot sprayed with lead arsenate-bentonite had the next most seriously or 65 percent injured foliage. The lead arsenate-summer oil-zinc sulfate treated plots had the least amount of arsenical burn of leaves of all the plots and the leaves remained in a normal condition on the trees until frost.

Data of the various insecticide tests for the control of codling moth in the Blair experimental orchard at Blair, Kansas, are recorded in table II.

TABLE II. Summary of all dropped and harvested apple counts for season of 1942, and percentages of wormy, stung and clean apples, and residue analyses.

| | Insecticide treatment in pounds per 100 gallons of water | Total Number Per Plot | Percent | | | $As_2O_3$ (grains per lb.)[1] | |
|---|---|---|---|---|---|---|---|
| | | | Wormy | Stung | Clean | Before Washing | After washing |
| 1 | Tritox 4 lbs. | 1172 | 29.5 | 36.4 | 34.1 | 0.2447 | less than 0.001 |
| 2 | Lead arsenate 4 lbs. plus Wyoming bentonite 2 oz. | 1142 | 3.5 | 16.3 | 80.2 | 0.3303 | 0.01 |
| 3 | Lead arsenate 4 lbs. | 1092 | 4.1 | 16.9 | 79.0 | 0.2660 | 0.009 |
| 4 | Lead arsenate 4 lbs. plus Superla oil 1 qt. plus zinc sulfate 1/4 lb. Oil left out after 2nd cover spray. | 1102 | 3.9 | 15.3 | 80.8 | 0.3825 | 0.02 |
| 5 | Lead arsenate 4 lbs. plus Superla oil 1 qt. plus zinc sulfate 1/4 lb. Oil left out after 3rd cover spray. | 1140 | 2.6 | 11.1 | 86.3 | 0.2163 | 0.015 |
| 6 | Lead arsenate 4 lbs. plus Superla oil 1 qt. plus zinc sulfate 1/4 lb. Oil left out after 4th cover spray. | 1189 | 6.2 | 13.0 | 80.8 | 0.2580 | 0.023 |

TABLE II. Continued

| | Insecticide treatment in pounds per 100 gallons of water | Total Number Per Plot | Percent | | | $As_2O_3$ (grains per lb.)1/ | |
|---|---|---|---|---|---|---|---|
| | | | Wormy | Stung | Clean | Before washing | After washing |
| 7 | Lead arsenate 4 lbs. plus Superla oil 1 qt. plus zinc sulfate 1/4 lb. Oil left out after 5th cover spray. | 1104 | 2.7 | 12.7 | 84.6 | 0.2650 | 0.025 |

1/ Residue analyses were made by Dr. B. L. Smits of the Department of Chemistry, Kansas State College.

## General Observations

Dropped apples were counted during the summer on July 17 and 31 and August 21. A windstorm July 13 made clean, dropped apples of the first count of no significance. only the wormy fruits were counted. Most of the clean dropped apples counted on July 31 were knocked from the branches by the spray rig.

A week to two weeks previous to the time of harvest excessive dropping of mature fruit takes place if the weather is hot following a period of abundant moisture and this fruit is known as the preharvest drop.

The preharvest drop of Jonathan apples was the worst in many years. Many growers picked up two-thirds of the crop from the ground.

## Discussion

The objects of the tests of the spray materials for the season of 1942 were to determine the effectiveness in the control of codling moth, the relative freedom from spray injury of the foliage at the end of the spray season and the effect of oil upon arsenic residue removal, when used through the fifth cover spray.

Arsenic tolerance is 0.025 grains of arsenic per pound of apples, which is allowed by the Federal Security Agency of the United States Department of Agriculture. The use of oil in the fourth and fifth cover sprays increases the difficulty of removing the arsenic load from the harvested apples by the standard acid wash.

On August 5 a leaf miner outbreak was noted to be well under way. The larva of this pest burrows beneath the epidermis of the leaf and feeds upon the leaf tissues between the epidermis. When the larva has completed its feeding period, it leaves the leaf by lowering itself to the ground, by means of a thread. This skeletonizing of the leaves infested by leaf miners causes additional arsenical burning, resulting in much loss of foliage. An infestation of Jonathan leafspot or frogeye disease also was present during the 1942 season to contribute further foliage injury.

All materials tested except the tricalcium arsenate-bentonite combination (Tritox) gave effective control of codling moth. Some variations in the percentages of control expected occurred in the zinc sulfate-lead arsenate-summer oil tests. The plot receiving two summer oil sprays rated a higher percentage of effectiveness in control than the plots receiving three and four summer oil sprays. These variations in percentage of control obtained were of a 6 percent spread between the most effective and the least effective of the lead arsenate-zinc sulfate-summer oil plots.

Summary

The tricalcium arsenate-bentonite (Tritox) plot was the least effective of all the spray combinations tested. Only 34.1 percent of clean fruit resulted from the use of this material. Arsenical burn was more severe on the foliage of this plot than it was with any of the other spray combinations tested.

The lead arsenate-bentonite mixture was slightly more effective in codling moth control than was lead arsenate alone. The foliage injury, however, was somewhat worse than on the lead arsenate alone plot.

The percentage spread in effective control obtained on the 4 lead arsenate-zinc sulfate-summer oil emulsion plots ranged from 80.8 percent to 86.3 percent clean fruit. The foliage on all these plots had less arsenical burn than on the tricalcium arsenate-bentonite (Tritox), lead arsenate-bentonite, or lead arsenate alone plots. Less defoliation took place on the lead arsenate-zinc sulfate-summer oil emulsion plots than on the other plots.

The percentage spread in effective control of codling moth of the best lead arsenate-zinc sulfate-oil plot over lead arsenate alone was 7.3 percent. The percentage spread of wormy fruit on all plots containing some combination of lead arsenate ranged from 3.5 to 6.2 percent. The percentage spread of stung fruits ranged from 11.1 to 16.9 percent.

Fewer stung fruits resulted on the plots receiving the greater number of lead arsenate-zinc sulfate-summer oil emulsion sprays. The stings on all plots containing some combination of lead arsenate were light, the most of which were well healed over, difficult to observe and were still usuable fruit at harvest.

A disadvantage was apparent for all of the zinc sulfate plots in that the fruit which matured later due to foliage excellence, had less color and appeared less desirable when compared to the better colored fruit on the tricalcium arsenate-bentonite (Tritox), lead arsenate-bentonite and lead arsenate alone plots. However, one orchardist in Doniphan County sprayed with the lead arsenate-zinc sulfate-summer oil emulsion combination. When the Jonathan variety began to drop rapidly, this orchardist sprayed with one of the hormone sprays. This resulted in the fruit remaining on the tree until adequate color was obtained.

All samples of harvested apples, when analysed for arsenic load, had more than the tolerance of 0.025 grains of arsenic per pound of fruit. The acid wash reduced all of them to or below the tolerance. The lead arsenate-zinc sulfate-summer oil combination with 5 oil sprays, when washed, still had a residue of 0.025 grains of arsenic per pound of fruit.

## KENTUCKY

P. O. Ritcher, Kentucky Agricultural Experiment Station, Lexington

There was a heavy carryover of codling moth worms in 1942, despite the cold winter, and a heavy, prolonged, emergence of spring brood moths. In general, the spring and summer were characterized by excessive temperature and precipitation. In many orchards, weather conditions undoubtedly contributed to the reduction in second and third brood worm damage and resulted in one of the best apple crops in years. Where early lead arsenate sprays were poorly timed, however, severe worm damage resulted. The unfavorable character of the season for late codling moth development is reflected in the unusually small number of worms wintering-over for next year.

At Fulton, moth emergence began April 27; at Princeton, April 30; at Louisville, April 28; and at Lexington, May 5. At Princeton, emergence of spring brood moths was heavy during May and the first half of June while first generation moths emerged in numbers during the first two weeks of July. At Lexington, during the emergence of spring brood moths, two main peaks were evident, one coming the middle of May and a second extending from the last week in May through the first week of June. Emergence of first generation moths was light at Lexington.

No detailed control experiments were carried on. At Lexington records were obtained on the control afforded by an intensive, lead arsenate-weak bordeaux spray program consisting of a calyx spray; five, first-brood, cover sprays; and three, second-brood sprays. One-half per cent summer oil was included in the third to fifth, first-brood cover sprays. Red Delicious in the old Station orchard had 45 per cent clean fruit, 41 per cent with stings and 14 per cent wormy. The same variety in the new orchard had 82.3 per cent clean fruit, 16.8 per cent with stings and 0.9 per cent wormy. Roman Beauty in the old Station orchard had 81.1 per cent clean fruit, 16.8 per cent with stings and 1.1 per cent wormy while Roman Beauty in the new orchard had 72.2 per cent clean fruit, 25.5 per cent with stings and 2.3 per cent wormy.

MARYLAND

C. Graham, Maryland Agricultural Experiment Station, College Park.

The experiments were laid out in two blocks, each having five rows of trees. Each row contained approximately thirty trees, about equally divided between Nero, Rome, and Stayman varieties. The entire experiment received the regular schedule of five cover sprays and some of the plots had additional materials combined with two or more of the regular sprays.

Rows no. 1 and 6 received the regular schedule plus one pint of Black Leaf 40 per 100 gallons, added to the first and second covers and at the peak of the second brood emergence.

Rows no. 2 and 8 received only the regular schedule.

Rows no. 3 and 7 received the regular schedule plus 1 1/2 pints of D-X per 100 gallons in the first and second cover and one at the peak of emergence of the second brood moths.

Rows no. 4 and 10 received the regular schedule plus one gallon of summer oil per 100 gallons in the first and second cover sprays.

Rows no. 5 and 9 received the regular schedule plus 1 pint of Black Leaf 40 and 1 gallon of summer oil per 100 gallons in the first and second cover sprays.

Examinations were made on every apple including the drops from a Rome, Nero and Stayman tree from each row. The results are shown in the following table:

| Materials used | Varieties | No.apples examined | Av. % worms | Av. % stings | Av.% clean fruit | Av. arsenical analysis | Av. lead analysis |
|---|---|---|---|---|---|---|---|
| Regular schedule | Nero, Rome Stayman | 2823 | 32.88 | 28.23 | 38.89 | .025 | .061 |
| D-X plus regular schedule | " | 3586 | 29.38 | 34.64 | 35.98 | .036 | .083 |
| Nicotine plus regular schedule | " | 2534 | 24.19 | 28.91 | 46.90 | .029 | .061 |
| Oil plus regular schedule | " | 4986 | 25.99 | 23.40 | 50.61 | .035 | .076 |
| Oil plus regular schedule + BL40 | " | 4512 | 19.66 | 26.63 | 53.71 | .033 | .070 |

The figures in the table are probably not a true picture of the value of the supplementary materials. The plots treated with Black Leaf 40, summer oil, and summer oil plus Black Leaf 40 gave an increase in clean fruit over the regular schedule in spite of the cross over of moths from one row to another. It is reasonable to assume that if the entire orchard had been treated with the regular schedule plus one of the supplementary materials that the percent of clean fruit would have been higher than was obtained from the plots.

At harvest time, an arsenical and lead analysis was made on each variety, namely Nero, Rome and Stayman from each plot. The average of the analysis of the three varieties from each plot is also given in Table 1.

In previous years, attempts were made to collect dead codling moths from trees sprayed with a mixture containing Black Leaf 40. Large sheets were spread under the trees while they were being sprayed, but in no instance was any dead moths found on the sheets.

In 1942 at the peak of first brood emergence, newly emerged moths were placed in small screen wire cages, and the cages were hung in the top of apple trees. The cages were allowed to remain in the tree for several hours after they were sprayed, then removed and the dead moths counted. The results are shown in the following table.

| Materials used | No. moths placed in cage | No. living | No. dead | % dead |
|---|---|---|---|---|
| Black Leaf 40 plus regular schedule | 22 | 5 | 17 | 77.30 |
| Black Leaf 40 plus oil plus regular schedule | 37 | 4 | 33 | 89.19 |
| D-X plus regular schedule | 18 | 13 | 5 | 27.77 |

MASSACHUSETTS

A. I. Bourne, Massachusetts Agricultural Experiment Station, Amherst.

I. On the whole the season followed very closely the general pattern of 1941 in that an unusually early spring stimulated seasonal development of both insects and many of the crops with which they are associated. The development of codling moth and of the orchards in the state fell into this category. The early applications for codling moth control in 1942 occurred within one or two days of the corresponding applications in 1941 and were, on the whole, about a week or ten days earlier than what we consider normal seasons. The late summer applications, however, were applied more nearly on normal dates and indicated that, as we have often found, as the season advanced toward mid-summer, conditions became more normal so that the behavior of the insect in late July and throughout the first part of August was along the same general lines as in normal seasons. In both instances where comparative records were available, it did not appear that codling moth was the cause of quite as much damage as occurred in the previous year which in itself was not to be considered one of the bad codling moth years.

III. In orchard tests to determine the value of modification in the spray schedule, and of various non-arsenicals for codling moth control, the present standard schedule recommended for Massachusetts conditions was compared with those in which fixed nicotine and a pyrethrum-rotenone combination were used as a supplement for lead arsenate in late summer applications.

One application of a fixed nicotine (14 percent nicotine), Black leaf 155, replacing lead arsenate in the 4th cover spray reduced codling moth damage to 1.5 percent as compared with 4 percent following the present standard schedule. Fruit from unsprayed checks in this block showed 19.4 percent injury by codling moth.

In a plot in which fixed nicotine replaced lead arsenate in the 4th cover spray and was also applied in mid-August, samples of fruit at harvest showed less than 6 apples per 1,000 damaged by codling moth.

A modified schedule in which a commercial pyrethrum-rotenone combination DX was applied in the 2d, 3d, 4th and mid-August sprays held the codling moth damage to 0.08 percent. Lead arsenate was used with this combination but at reduced strength.

An application of fixed nicotine between the 2d and 3d cover sprays to furnish protection between June 12 and July 9 gave increased protection against codling moth, although the effect was not so pronounced as would be the case in a year when codling moth presented a more serious problem.

All of these materials were used with the wettable sulfur for scab control, proved entirely compatable with the fungicides, and held scab to less than 1 percent damage while samples from unsprayed trees showed 92 percent scabby fruit.

The results of these tests are tabulated as follows:

| Schedule | Percentage of fruit clean. | Percentage of fruit showing injury by |  |  |
|---|---|---|---|---|
|  |  | Curculio | Codling moth | Scab |
| 1. Standard schedule | 86 | Trace | 3.5 | Trace |
| 2. Standard schedule replaced by Black Leaf 155 in 4th Cover. | 88.1 | Trace | 1.5 | Trace |
| 3. Standard schedule replaced by Black Leaf 155 in 4th Cover - with a mid-August application of Black Leaf 155. | 88 | 1.6 | Trace | 3 |
| 4. Standard schedule through 1st Cover Spray; DX in modified schedule in 2d, 3d, 4th Covers and mid-August application | 92 | 0.8 | 0.8 | Trace |
| 5. Standard schedule. Black Leaf 155 applied between 2d and 3d Cover Sprays. | 87 | 1.9 | 2.8 | --- |
| 6. Check | 3.1 | 30.6 | 19.4 | 92 |

Note: Red bugs caused more damage in this orchard than all other insect pests combined. It varied from 5 to 8 percent and was due to the fact that in an effort to lower operating costs, no nicotine was used in the Pink application. Otherwise the percentage of clean fruit would have run consistently over 90 percent in all plots except the check.

## MICHIGAN

Ray Hutson, Michigan Agricultural Experiment Station, East Lansing.

I. Codling moth abundance during 1942 conformed pretty closely to the 5 year average with a few spotted heavy infestations and the usual early September upsurge in stings for the three southwestern counties.

III. No experimental set-up.

A. We did conduct a survey indicating that from 200 growers selected at random; 51 percent considered this year's infestation severe, 49 percent considered this year's infestation average, 69.5 percent used lead arsenate alone, 8.5 percent used lead arsenate plus nicotine in 2nd and 3rd covers, 22 percent used a fixed nicotine schedule after 2 sprays lead arsenate, 88 percent used 5 or more sprays for codling moth.

B. A noticeable increase in banding

IV. Ample insecticide supply.

## MISSOURI

L. Haseman, Missouri Agricultural Experiment Station, Columbia

I. Seasonal conditions and status of codling moth infestations during 1942.

Weather conditions in the early part of the season were rather favorable for control. Moths began emerging at about the normal time, and plenty of spaced rains aided with the spray control. Control of first and second generation worms was splendid, but third generation worms found natural conditions more to their liking. As a result, we had too many late worms in most of our commercial orchards. In the southwest part of the state, however, cool weather in September slowed down late worm work. In all parts of the state the prompt marketing of the crop and the local demand for culls and wormy fruit resulted in the removal from the orchard and packing sheds of a much larger per cent of the late worms than in a normal year. As a result, our carryover of worms into 1943 will be greatly reduced.

II. Studies on codling moth biology or behavior.

No detailed work was undertaken this year, though bait jars were used in all experimental orchards to follow daily moth activity.

III. Results of control experiments.

A. Control by insecticides.

Lead arsenate and fixed nicotine, with the addition of spreaders, stickers, and deposit builders, were given most attention in our spray control work this year. The results are given in the accompanying tables.

(a) Experimental set-up:--In all of our experimental orchards we use plats consisting of adjoining rows of trees of the same variety or varieties, and usually include as many trees in each plat as a sprayerful of the different insecticides will treat. Uniform count trees are then selected scattered throughout the length of the plat. All drop fruits throughout the summer are included, along with the picked fruit at harvest time, in determining results.

(b) Unusual conditions:--The light crop helped to account for the higher than normal per cent of wormy fruit. Abundant rainfall early in the season aided control. Late summer dry spell and late frost favored late worms in most orchards. Prompt disposal of crop removed many late worms from the orchards.

(c) Injury to foliage or fruit:--Lime as a "safener" with lead arsenate and lead arsenate-oil was less effective than zinc bordeaux in protecting foliage and fruit from burn. Brown sugar plats showed worse burn than other plats. Fixed nicotine plats and those with lead arsenate early and nicotine late showed least spray injury.

(d) Spray residue at harvest time:--Residue studies were made only in the Seneff Orchard in the southwest part of the state. The following is a record of lead residue on the various plats sampled on August 26, 1942: Plat 3 - .102 gr. per lb., Plat 4 - .051, Plat 5 - .099, Plat 6 - .113, Plat 7 - .120. All residues were brought considerably below the tolerance by washing.

B. Control by means other than spraying.

No detailed work was undertaken, but scraping and banding, packing shed screening, and orchard sanitation were used to supplement spray control.

IV. Experience of growers in obtaining insecticides and spray equipment during 1942.

Missouri growers had no serious trouble in getting spray materials and equipment and repair parts in 1942.

## LUKE ORCHARD, CLARKSVILLE, MO.

Variety: Jonathan

| Plat | Treatment (Quantities are for 100 gallons) | Total Apples | % Clean | % Stung | % Wormy |
|---|---|---|---|---|---|
| 1 | LEAD ARSENATE AND LIME<br>3 lbs. lead arsenate, 2 lbs. lime, 6 lbs. Kolofog in 1st and 2nd covers. 3 lbs. lead arsenate and 2 lbs. lime in 3rd, 5th, and 6th covers. 3 lbs. lead arsenate, 2 lbs. lime, and 4 lbs. Kolofog in 4th cover. | 5016 | 80.5 | 7.8 | 4.5 |
| 2 | LEAD ARSENATE, LIME, AND SUMMER OIL<br>Same as Plat 1 except that 1 gallon of oil was added in 3rd cover and 3 quarts oil in the 6th cover. | 4318 | 69.0 | 8.0 | 5.1 |
| 3 | LEAD ARSENATE, LIME, OIL, & BROWN SUGAR<br>Same as Plat 2 except that 4 lbs. brown sugar was added in the last four covers, and oil was omitted from 6th cover. | 3400 | 68.9 | 6.8 | 4.7 |
| 4 | LEAD ARSENATE, LIME, OIL, BROWN SUGAR, & SASSAFRAS<br>Same as Plat 3 except that 2 oz. oil of sassafras was added in 3rd and 5th covers, and 1 oz. in 6th. | 3032 | 57.8 | 11.3 | 7.5 |
| 5. | BLACKLEAF 155 (4.75% nicotine) & OIL<br>Same as Plat 1 in 1st cover. 8 lbs. 155 and 6 lbs. Kolofog in 2nd cover. 6 lbs. 155 and 1 gal. oil in 3rd cover. 6 lbs. 155 and 1/2 gal. oil in 4th, 5th, and 6th covers. | 3424 | 61.68 | 6.1 | 19.4 |
| 6 | BLACKLEAF 155 (14% nicotine) & OIL<br>Same as Plat 1 in 1st cover. 2 lbs. 155 and 6 lbs. Kolofog in 2nd cover. 2 lbs. 155 and 1 gal. oil in 3rd cover. 2 lbs. 155 and 1/2 gal. oil in the 4th, 5th, and 6th covers. | 4471 | 70.6 | 5.8 | 15.4 |

## LUKE ORCHARD, CLARKSVILLE, MO. (Continued)

| Plat | Treatment (Quantities are for 100 gallons) | Total Apples | % Clean | % Stung | % Wormy |
|---|---|---|---|---|---|
| 7 | LEAD ARSENATE AND ZINC BORDEAUX<br>Same as Plat 1 in first two covers. Same amounts of lead arsenate used in next 4 covers but with 1 lb. zinc sulfate and 1 lb. lime. 2 lbs. B.L. 155 (14%) in 7th cover. | 6933 | 77.58 | 10.5 | 7.3 |
| 8 | LEAD ARSENATE AND ZINC BORDEAUX<br>Same as Plat 7 except that 2 lbs. zinc sulfate and 2 lbs. lime were used instead of 1 lb., starting with the 3rd cover. 3 lbs. B.L. 155 (14%) in 7th cover. | 782 | 59.10 | 11.5 | 14.3 |
| 9 | LEAD ARSENATE ONLY<br>Same as Plat 1 in 1st and 2nd covers. 3 lbs. lead arsenate in 3rd, 4th, 5th, and 6th covers. 3 lbs. B.L.155 (14%) in 7th cover. | 6657 | 85.10 | 6.4 | 4.9 |
| 10 | LEAD ARSENATE AND LIME<br>Same as Plat 6, except that 6 lbs. hydrated lime was added in 3rd, 4th, 5th, and 6th covers. | 3785 | 65.60 | 14.74 | 8.7 |

HARVEST DATE: September 11

Spray Dates:

Calyx ----------- April 29
1st cover -------- May 9
2nd cover -------- May 19
3rd cover -------- June 1
4th cover -------- June 17
5th cover --- July 2
6th cover --- July 20
7th cover --- Sept. 2

PIONEER ORCHARDS, CAPE GIRARDEAU, MO.

Variety: Jonathan

| Plat | Treatment (Quantities are for 100 gallons) | % Clean | % Stung | % Wormy |
|---|---|---|---|---|
| 1 | LEAD ARSENATE AND LIME<br>3 lbs. of lead arsenate and 3 lbs. lime in all covers. | 42.52 | 45.76 | 11.72 |
| 2 | LEAD ARSENATE, LIME, AND SUMMER OIL<br>Same as Plat 1 except that 3 quarts of summer oil was used in the 3rd and 7th cover. | 69.16 | 25.38 | 5.46 |
| 3 | LEAD ARSENATE, LIME, AND D-X<br>Same as Plat 1 except that 1 1/2 pints of D-X were used in the 3rd and 7th covers. | 57.13 | 33.35 | 9.52 |
| 4a | BLACKLEAF 155 (14%) AND SUMMER OIL<br>3 lbs. lead arsenate and 3 lbs. lime in 1st cover; 3 lbs. Blackleaf 155 in 2nd cover; 2 lbs. Blackleaf 155 in all remaining covers plus 2 quarts summer oil in the 3rd and 7th. | 61.76 | 28.46 | 9.78 |
| 4b | BLACKLEAF 155 (14%). SUMMER OIL, & BROWN SUGAR<br>Same as Plat 4a except that 4 lbs. brown sugar was added in all covers except 1st. cover. | 60.54 | 28.68 | 10.78 |
| 4c | BLACKLEAF 155 (14%), SUMMER OIL, & MOLASSES<br>Same as Plat 4a except that 3 quarts molasses were added in all covers except 1st cover. | 57.68 | 30.76 | 11.56 |

COUNTS WERE MADE AUGUST 29, 1942

Spray Dates:

Calyx -------- April 25
1st. cover --- May 7
2nd. cover --- May 14
3rd. cover --- May 25
4th. cover ---- June 4
5th. cover ---- June 18
6th. cover ---- June 29
7th. cover ---- July 15

## STATE FRUIT EXPERIMENT STATION, MOUNTAIN GROVE, MO.

Variety: Champion

| Plat | Treatment (Quantities are for 100 gallons) | Total Apples | % Clean | % Stung | % Wormy |
|---|---|---|---|---|---|
| 1 | LEAD ARSENATE, LIME, SUMMER OIL & DX<br>3 lbs. lead arsenate and 3 lbs. lime in 1st, 3rd, and 4th covers. 3lbs. lead arsenate, 1 1/2 pints DX, and 3/4 gal. summer oil in 2nd, 5th, and 8th covers. 2 1/2 lbs. lead arsenate and 2 1/2 lbs. lime in 6th and 7th covers. | 6793 | 31.23 | 60.09 | 17.27 |
| 2 | LEAD ARSENATE AND LIME<br>Same as Plat 1 except that no summer oil or DX was used. | 6848 | 28.32 | 61.07 | 24.02 |
| 3 | LEAD ARSENATE, LIME, & SUMMER OIL<br>Same as Plat 1 except that no DX was used. | 6794 | 54.75 | 37.27 | 12.44 |
| 4 | LEAD ARSENATE, LIME, SUMMER OIL, & SACCHARIN.<br>Same as Plat 3 except that 1/2 oz. saccharin was added in the first 6 covers, and 1 oz. was added in the 7th and 8th covers. | 3803 | 39.80 | 51.82 | 16.79 |
| 5 | LEAD ARSENATE, LIME, SUMMER OIL (1st brood) NICOSOL (2nd and 3rd broods)<br>Same as Plat 3 for first 4 covers. 3/4 gal. Nicosol and 1 1/2 lbs. Nicosol powder in 5th and 8th covers. 1/2 gal. Nicosol and 1 lb. Nicosol powder in 6th and 7th covers. | 5774 | 33.65 | 40.23 | 37.63 |
| 6* | INVERTED LEAD ARSENATE & FLOCCULATED BENTONITE<br>Same as Plat 1 in the 1st cover. 4 lbs. lead arsenate, 1/2 lb. pine tar soap flakes, and 1/2 gal. summer oil in 2nd. 3rd, 5th, and 8th covers. 5 lbs. bentonite, 2 1/2 lbs. pine tar soap flakes, 1 lb. aluminum sulfate, and 1 quart soy bean oil in 4th, 6th, and 7th covers. | 2300 | 6.66 | 70.13 | 58.85 |

## STATE FRUIT EXPERIMENT STATION, MOUNTAIN GROVE, MO. (Continued)

Variety: Champion

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HARVEST DATE: Sept. 18

Spray Dates:

Calyx ------- May 4 | 4th cover -- June 18 | 8th cover- Aug. 29
1st cover.-- May 14 | 5th cover -- July 3
2nd cover -- May 23 | 6th cover -- July 29
3rd cover -- June 1 | 7th cover -- Aug. 17

Note: Due to the fact that a severe scab infestation severely injured the foliage, no observations as to foliage damage by spray materials were possible, and the fruit ripened about two weeks ahead of the normal ripening season.

* Plat 6 was separated from the other plats and sustained a very heavy worm attack.

## SENEFF ORCHARD, MARIONVILLE, MO.

Variety: Jonathan

| Plat | Treatment (Quantities are for 100 gallons) | Total Apples | % Clean | % Stung | % Wormy |
|---|---|---|---|---|---|
| 1 | BLACKLEAF 155 (14% nicotine) AND OIL<br>3 lbs. Blackleaf 155 in 1st cover. 2 lbs. Blackleaf 155 and 3 quarts oil in 2nd, 3rd, and 7th covers. 2 lbs. Blackleaf 155 and 1 quart oil in 4th, 5th, 6th, and 9th covers. | 3381 | 32.6 | 27.4 | 51.0 |
| 2 | LEAD ARSENATE, LIME, PARIS GREEN<br>3 lbs. lead arsenate and 3 lbs. lime in 1st cover. 3 lbs. lead, 3 lbs. lime, and 2/5 lb. paris green in 2nd, 3rd, and 7th covers. 2 1/2 lbs. lead and 2 1/2 lbs. lime in 4th, 5th, 6th, and 8th covers. 2 lbs. lead arsenate and 2 lbs. lime in 9th cover. | 3997 | 9.8 | 66.4 | 60.0 |
| 3 | LEAD ARSENATE AND LIME<br>Same as for Plat 2 except that no paris green was used. | 5053 | 4.8 | 69.4 | 71.0 |
| 4 | LEAD ARSENATE, LIME, AND OIL (1st brood) BLACKLEAF 155 AND OIL (2nd and 3rd broods)<br>Same as Plat 6 in first four covers. Same as Plat 1 in last five covers. | 3305 | 30.1 | 35.8 | 51.8 |
| 5 | LEAD ARSENATE, LIME, OIL, BROWN SUGAR<br>Same as Plat 6 except that 3 lbs. brown sugar was added in each cover spray. | 5302 | 23.0 | 58.0 | 50.5 |
| 6 | LEAD ARSENATE, LIME, OIL<br>Same as Plat 2 except that no paris green was used, and 3 quarts oil were added in the 2nd, 3rd, and 7th covers. | 4246 | 17.8 | 64.4 | 48.4 |

SENEFF ORCHARD, MARIONVILLE, MO. (Continued)

Variety: Jonathan

| Plat | Treatment (Quantities are for 100 gallons) | Total Apples | % Clean | % Stung | % Wormy |
|---|---|---|---|---|---|
| 7 | LEAD ARSENATE, SAFE-N-LEAD, SPRAYLASTIC, AND SUMMER OIL EMULSION<br>4 lbs. Sherwin -Williams lead arsenate, 1 1/3 lbs. Safe-N-lead, and 1 pint Spraylastic in 1st cover. 4 lbs. SW lead arsenate, 1 1/3 lbs. Safe-N-lead, 1 1/3 pints Spraylastic, & 2 qts. Summermulsion in 2nd and 3rd covers. (7th cover same but with only 3 lbs. lead) 3 lbs. SW lead arsenate, 1 lb. Safe-N-lead, & 1 pt. Spraylastic in 4th, 5th, 6th, and 8th covers. 2 lbs. SW lead arsenate, 2/3 lb. Safe-N-lead, & 7/8 pint Spraylastic in 9th cover. | 5232 | 16.4 | 65.4 | 48.2 |
| 8 | LEAD ARSENATE, LIME, OIL, LETHANE 60<br>Same as Plat 6 except that B-1956 summer oil was used, and 1 pint Lethane 60 was added in the 3rd, 2nd, and 7th and 8th covers. | 3310 | 5.7 | 79.0 | 68.3 |
| 9* | LEAD ARSENATE, LIME, ZINC SULFATE (5 covers) BLACKLEAF 155 AND OIL (3 covers)<br>3 lbs. lead arsenate and 3 lbs. lime in 1st cover. 3 lbs. lead, 1 lb. lime, and 1/2 lb. zinc sulfate in next five covers. 3 lbs. Blackleaf 155 in 7th and 9th covers. 2 lbs. Blackleaf 155 and 3 qts. oil in 8th. | 5004 | 13.0 | 62.7 | 57.9 |

HARVEST DATES: August 26 (Plats 2,3.5,6,& 8) Sept. 7 (Plats 1,4,7,& 9)

Spray dates:

Calyx ------- May 7
1st cover --- May 13
2nd cover --- May 21

3rd cover --- June 2
4th cover --- June 16
5th cover --- June 29

6th cover --- July 13
7th cover --- July 24
8th cover --- Aug. 8
9th cover --- Aug. 24

* Dates are only approximate for Plat 9

## NEW JERSEY

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### I Seasonal Conditions and Codling Moth Abundance.

Codling moth pupation and emergence in central and southern New Jersey began approximately two weeks earlier than normal. This early emergence was followed by favorable weather for moth development during May, June and July. Beginning the last five days of July and continuing through the first three weeks of August a cool, rainy period set in which was distinctly unfavorable to moth development and activity. At Glassboro from July 27 to August 24 inclusive measurable precipitation occurred on 15 of the 29 days. amounting to over nine inches of rainfall, which is more than double the average annual rainfall for August. This period was followed by dry and warm periods of weather during the last week of August and the first two weeks of September which was distinctly favorable to codling moth activity and egg laying. The excessive rainfall in August served to reduce the protective spray coatings applied in July by washing off the coating direct and by causing the fruit to increase in size during August and September. The net result was that few orchards had sufficient spray material on the fruit to prevent worm entry from the delayed egg hatch, which occurred in late August and the first half of September. In a number of orchards where no additional sprays were applied following the rainy period in August the loss from codling moth attack was serious.

### III Results of control experiments.

#### A. Control by insecticides.

(1) Lead Arsenate. A study of correctives for arsenical injury was carried on for a third season in cooperation with the Department of Plant Pathology. The plot tests in 1941 had shown that a weak bordeaux (1/2-2-100) gave the best protection from foliage injury but was inferior to lime alone from the standpoint of fruit russet. In the 1942 tests different amounts of lime (2, 4 and 6 pounds to each one hundred gallons of lead arsenate spray) were compared to the same amounts of lime plus 1/2 pound of copper sulfate. In addition, a 1/2-2-100 zinc sulfate-lime plot was included in the set up, making a total of seven plots. Two sets of plots were run in two different orchards; in one orchard Rome and Stayman were the test varieties and in the other orchard Rome and Delicious were the varieties.

In both sets of plots lead arsenate plus summer oil was used, the oil being used in two sprays at the peak of first brood egg laying and in one spray at the peak of second brood egg laying. A total of seven cover sprays--four for the first brood and three for the second--were applied. The different corrective treatments were begun at the third cover spray. All plots received hydrated lime as the corrective in the first two cover sprays.

The last cover spray was applied July 31st and foliage injury counts were made on all the plots the first of September. In making the counts twigs and spurs were selected at random on two trees in each plot and a total of 1000 leaves examined on each plot. The leaves were scored according to the percentage area injured. The results from the tests at Glassboro are set forth in the accompany table. It will be seen from these results that foliage injury was not severe in any of the plots on either the Delicious or Romes. The results at Glassboro and at Masonville showed that lime alone was slightly inferior to lime plus 1/2 pound of copper sulfate. Four and six pounds of lime, with or without copper sulfate, appeared to be slightly superior to two pounds of lime. There was not enough russet on the fruit to warrant making counts. The results in 1942 plus the results of previous seasons work leads us to recommend a 1/2-4-100 bordeaux as the best arsenical corrective instead of 1/2-2-100 bordeaux recommended previously.

Table - Condition of foliage on arsenical corrective plots in the Alvin Magee orchard, Glassboro. Plots sprayed with lead arsenate-oil first and second broods. One thousand leaves examined each plot on September 1st.

| Plot No. | Corrective | Uninjured Leaves | Less than 10% Injured | 10-25% Injured | 25-50% Injured | Over 50% Injured |
|---|---|---|---|---|---|---|
| | | | Delicious | | | |
| 1 | Lime 2 lbs. | 324 | 400 | 124 | 62 | 90 |
| 2 | Lime 2 lbs.,<br>$CuSO_4$ 1/2 lb. | 506 | 327 | 90 | 50 | 27 |
| 3 | Lime 4 lbs.,<br>$CuSO_4$ 1/2 lb. | 635 | 283 | 41 | 17 | 24 |
| 4 | Lime 6 lbs.,<br>$CuSO_4$ 1/2 lb. | 755 | 209 | 26 | 12 | 8 |
| 5 | Lime 2 lbs.,<br>$ZnSO_4$ 1/2 lb. | - | - | - | - | - |
| 6 | Lime 4 lbs. | 465 | 329 | 110 | 51 | 55 |
| 7 | Lime 6 lbs. | 525 | 292 | 104 | 47 | 32 |
| | | | Romes | | | |
| 1 | Lime 2 lbs. | 319 | 488 | 31 | 60 | 104 |
| 2 | Lime 2 lbs.,<br>$CuSO_4$ 1/2 lb. | 543 | 392 | 32 | 14 | 22 |
| 3 | Lime 4 lbs.,<br>$CuSO_4$ 1/2 lb. | 680 | 263 | 25 | 11 | 21 |
| 4 | Lime 6 lbs.,<br>$CuSO_4$ 1/2 lb. | 785 | 176 | 25 | 5 | 9 |
| 5 | Lime 2 lbs.,<br>$ZnSO_4$ 1/2 lb. | 482 | 444 | 35 | 9 | 30 |
| 6 | Lime 4 lbs. | 333 | 555 | 74 | 18 | 20 |
| 7 | Lime 6 lbs. | 626 | 314 | 38 | 8 | 14 |

The use of 3/4 pint of nicotine sulfate to the regular lead arsenate or lead arsenate-oil sprays at the peak of first brood sprays is recommended in orchards where codling moth is a serious problem. In many of the orchards of southern New Jersey this recommendation is followed. This past season about 12 of the so-called "Speed Sprayers" were operated in orchards of central and southern New Jersey. In the majority of these orchards nicotine was used in one or more of the first brood cover sprays. In general the results with these sprayers were good. No orchard sprayed with these sprayers failed to bring through a commercially clean crop of apples. It is believed the addition of nicotine to the lead arsenate-oil improved the efficiency of the spray; however, the principal reasons for the improvement in pest control in these orchards was the speed and thoroughness of coverage possible with this type of equipment.

(5) Materials for use against mature larvae or pupae in cocoons.

Laboratory and field experiments conducted during the last year have shown that it is possible to kill codling moth larvae hibernating on apple trees by spraying with organic solvents, the cheapest of which proved to be kerosene. The toxicity of kerosene may be further augmented by incorporating in it various toxic chemicals such as: dichorethyl ether, dinitro cresol, methyl chloroacetate, etc. From the results thus far obtained, however, it became evident that in order to kill all, or the major proportion of the overwintering larvae, it will be necessary to spray the entire tree, because many larvae were found hibernating on high limbs, especially in old trees. This makes the problem more difficult, since the fruit buds and to a lesser extent the leaf buds are, unlike the bark, severely injured by the high concentrations of kerosene and other spray materials necessary to kill the larvae. Experiments are now in progress with other solvents and organic chemicals with the object of finding an insecticide or a combination of insecticides possessing high toxicity to codling moth larvae and producing no injury to dormant buds.

B. Control by means other than spraying.

In the pool of information for 1938 to 1940 results were given of an extensive project on biological control of the codling moth in sprayed and unsprayed orchards. It was noted that larval parasitism was more prevalent in unsprayed orchards than in sprayed orchards but that fruit harvested from unsprayed orchards was 90 to 100% wormy. Few parasites were found in sprayed orchards.

During the summer of 1940 considerable numbers of hyperparasites, Perilampus spp., were encountered in the unsprayed blocks of trees. Studies of these hyperparasites have been underway during the past two years in an effort to determine whether these insects are important in keeping primary parasitism of codling moth larvae at a low level. In the Glassboro, N. J. area primary parasitism by Ascogaster quadridentatus may effect as high as 60% of the codling moth larvae but rarely goes above this level. Indications are that these perilampids are effective in reducing the numbers of Ascogaster particularly when the latter is on the increase. Perilampus spp. are highly specialized insects with remarkable habits especially fitting them for their mode of life. A summary of the biology and economic importance of these hyperparasites is being prepared.

## IV. Experience of growers in obtaining insecticides and spray equipment.

New Jersey growers did not experience any great difficulty in obtaining the principal insecticide materials used for codling moth control. These included lead arsenate, summer oil, nicotine and lime. No particular difficulty in obtaining equipment was experienced either except, perhaps, in obtaining parts and labor for repairs. For example, twelve of the new Speed Sprayers were purchased and delivered to New Jersey orchards during the 1942 season. During 1941 not a single sprayer of this type was to be found in New Jersey.

## NEW MEXICO

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## Codling-moth Investigations, Departments of Biology and Horticulture, New Mexico Agricultural Experiment Station.

The investigations of the past year emphasized the following features:

1. Small-scale comparisons of split schedules of insecticides designated to minimize arsenic residues in the College orchard at the Horticultural farm.

2. Large-scale tests of the effectiveness of insecticide combinations similar to those developed at State College, in the major apple-growing area of the State (i.e., San Juan Valley), these being applied according to timing schedules suggested by bait trap and trap band observations of the seasonal cycle.

3. Experiments designed to improve the attractiveness of bait traps which thus far have proved the most practical method for the timing of spray schedules.

These are reported in the order indicated above.

1. Table 1 presents the harvest data of the 8 spray schedules which were compared in the College orchard. All treatments were tested on the Arkansas Black and Stayman Winesap varieties. Each treatment was replicated 3 times and the data were analyzed by the variance method. It may be seen that the application of a calyx, 2 first-brood sprays, and 1 second-brood spray of lead arsenate followed by 4 sprays of nicotine-bentonite and summer oil (i.e., treatment 3), was significantly better than any of the other split schedules except

treatment 2, on the Arkansas Black variety, although not significally superior to the straight schedule consisting of calyx and 5 cover sprays of lead arsenate (i.e., treatment 1). The addition of molasses and fruit pectin (Certo) to lead arsenate in the first of the above combinations to form a so-called "palatable" spray (treatment 2) resulted in superior control in the Stayman variety, but was not significantly superior to the lead arsenate and summer oil followed by nicotine-bentonite (treatment 3) or the all-lead arsenate schedule (treatment 1). When the data of both Arkansas Black and Stayman varieties were combined and analyzed by the variance method, it was found that treatments 2 and 3 (that is, those receiving the extra lead arsenate cover spray) were significantly better than any other split schedule. The difference between treatments 2 and 3 and the straight schedules of 1 and 8 was in favor of 2 and 3, but was not great enough to be statistically significant.

Chemical analysis of Arkansas Black fruit harvested in October indicated that the arsenic residue (i.e., 0.015 grain) did not exceed the prescribed tolerance in the "palatable" schedule (treatment 2), but was slightly in excess (i.e. 0.025 grain) in the case of lead arsenate and oil applied as a calyx and first 3 cover sprays, followed by nicotine-bentonite and summer oil (treatment 3). All other split schedules were also below the prescribed tolerance for arsenic residue.

TABLE 1.--APPLE-SPRAYING EXPERIMENT, STATE COLLEGE, 1941

| Treatment number | Materials per 100 gallons of water | Mean percentages of salable fruit* (picked and windfall) | | |
|---|---|---|---|---|
| | | Arkansas Black | Stayman | Winesap |
| 1. | Calyx spray: Lead arsenate, 3 lbs.; kerosene soap spreader[1] Cover sprays 1-3: Lead arsenate, 3 lbs.; summer oil spreader, 1/2 gal. Cover sprays 4-5: Same as calyx. | 58.03 | 68.77 | |
| 2. | Calyx and 3 cover sprays:[2] "Palatable lead arsenate"[3] with 1 qt. Dowax spreader Cover sprays 4-7: 14% nicotine bentonite, 1 1/2 lbs., summer oil, 1/2 gal.. | 59.67 | 71.20 | |
| 3. | Calyx spray: Lead arsenate, 3 lbs.; summer oil, 1 gal. Cover sprays 1-3: Same as calyx.[2] Cover sprays 4-7: Nicotine bentonite, 1 1/2 lbs.; summer oil 1/2 gal. | 69.44 | 61.55 | 70.58 |
| 4. | Calyx spray: Lead arsenate, 3 lbs.; summer oil, 1 gal. Cover sprays 1-3: Same as calyx:[2] Cover sprays 3-6: Nicotine bentonite, 1 1/2 lbs.; summer oil, 1/2 gal. | 47.13 | 54.83 | 60.33 |

TABLE 1.--APPLE-SPRAYING EXPERIMENT, STATE COLLEGE, 1941
Continued

| Treatment number | Materials per 100 gallons of water | Mean percentages of salable*fruit (picked and windfall) Arkansas Black | Stayman | Winesap |
|---|---|---|---|---|
| 5. | Calyx spray: As in previous treatments. Cover sprays 1-2: Lead arsenate, 3 lbs. Cover sprays: 3: Cryolite, 4 lbs.; summer oil spreader, 1/2 gal. Cover sprays 4-6: Nicotine bentonite, 1 1/2 lbs.; summer oil, 1/2 gal. | 36.19 | 65.43 | |
| 6. | Calyx spray: As in previous treatments. Cover sprays 1-2: Lead arsenate, 3 lbs.; summer oil spreader, 1/2 gal. Cover sprays 3-6: Rotenone extract[4], 1 pt.; rotenone powder, 2 lbs.; Dowax,1 qt. | 31.14 | 38.91 | 40.87 |
| 7. | Calyx spray: As in previous treatments. Cover sprays 1-2: Lead arsenate, 3 lbs.; summer oil, 1/2 gal. Cover sprays 3-5: Cryolite, 4 lbs.; summer oil, 1/2 gal. | 46.81 | 56.77 | 71.33 |
| 8. | Calyx spray: Cryolite, 3 lbs.; kerosene soap spreader. Cover sprays 1-5: Cryolite, 4 lbs.; summer oil, 1/2 gal. | 50.38 | 64.81 | |
| 9. | Unsprayed check | 5.79 | 3.67 | 4.92 |
| | Difference necessary for 20:1 odds | 16.2 | 18.1 | 19.5 |

[1] Kerosene, 1/2 gal., tar soap flakes, 1 lb.

[2] In treatments 2 and 3 an extra cover spray was applied before the regular first cover (i.e., 7-9 days after the calyx spray).

[3] Lead arsenate, 3 lbs.; brown sugar, 10 lbs.; Certo, 8 ounces; Dowax, 1 qt.

[4] "Triple-kill" rotenone extract and "Cubor" rotenone powder.

* without stings or worms

2. Table 2 gives a comparative idea of the relative control obtained from the use of various modifications of the second-brood cover sprays in the San Juan Valley. When 3 second-generation sprays of lead arsenate were applied, from 59 percent to 70 percent of sound fruit was obtained and the percentage of stings varied from 21 to 30. Where three sprays of nicotine-bentonite and oil were applied for this generation, control was better, the percentages of sound fruit varying from 76 to 83, with 12 to 15 percent damaged by stings. In contrast, where only one second-brood spray was applied, the amount of sound fruit secured was 46 percent, of which 27 percent showed stings.

TABLE 2.--HARVEST RECORDS OF SPRAYED FRUIT IN SAN JUAN VALLEY ORCHARDS.

| Spray materials and quantities per 100 gallons of water | Varieties | Percent Sound Fruit | Percentage and types of injury | |
|---|---|---|---|---|
| | | | Percent worm entry | Percent of stings |
| Calyx and 6 cover sprays: Lead arsenate, 3 pounds summer oil, 1/2 gallon | Jonathan, | 70 | 9 | 21 |
| | Rome Beauty | 59 | 11 | 30 |
| Calyx and 5 cover sprays: Lead arsenate, 3 pounds; summer oil, 1/2 gallon | Rome Beauty | 63 | 15 | 22 |
| Calyx and 4 cover sprays: Lead arsenate, 4 pounds; Paris green, 1 pound; kerosene-soap spreader | Jonathan | 46 | 27 | 27 |
| Calyx and 1 cover spray: Lead arsenate, 3 pounds; summer oil, 1/2 gallon | Jonathan | 76* | 9 | 15 |
| 2-6 cover sprays: Nicotine-bentonite, 3 pounds; summer oil, 1/2 gallon | Jonathan | 83** | 5 | 12 |
| Calyx and 1 cover spray: Lead arsenate, 3 pounds; summer oil, 1/2 gallon; | Jonathan | 61 | 24 | 15 |
| 3-5 cover sprays: Black Leaf 155, 3 pounds; summer oil, 1/2 gallon | Rome Beauty | 58 | 21 | 21 |

*The nicotine-bentonite used was "Black Leaf 155."
**The nicotine preparation used was "Nicosol."

3. The experiments to increase the attractiveness of bait traps included 2 phases: (a) a further testing of the simpler organic acids at State College, followed by a comparison of the one proving most attractive with the standard cane sirup-sodium benzoate* bait in the San Juan Valley and (b) comparing the attractiveness of some of the more common amino acids when added to fermenting cane sirup and other sugar baits. Table 3 presents the data obtained from a comparison of 1 to 4 carbon fatty acids, alcohols, and esters by mixing them at 20 percent concentration with gum-tragacanth glycerine emulsion and exposing them in trap jars of the type described in the 48th Annual Report of the New Mexico Agricultural Experiment Station. A record of blowfly catches, as well as those of codling moth, was made during the State College tests, since these species become exceedingly abundant in cane sirup bait during warm weather and interfere with its attractiveness to codling moth. From these data it will be noted that glacial acetic acid far exceeded any of the related organic acids, alcohols, or esters in attractiveness and was 63 percent as attractive as fermenting cane sirup. It did not catch as many blowflies as did propionic acid or ethyl alcohol. Consequently this material was tested further in comparison with cane sirup bait during the months of July and August in San Juan County. Table 4 illustrates this comparison. It may be seen that 5 jars of acetic acid bait caught more than twice as many moths as the same number of jars of cane sirup. Its only disadvantage is that it is adversely affected by rainy weather and has to be renewed more frequently.

*Brer Rabbit cane sirup - 1 quart.
Sodium benzoate - 1 1/4 oz.
Water - 9 quarts.

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TABLE 3.--ATTRACTIVENESS OF 1 TO 4 CARBON ACIDS, ALCOHOLS, AND ESTERS TO CODLING MOTHS AND BLOWFLIES, STATE COLLEGE, APRIL 15 TO MAY 15, 1941

| Name of chemical | Total catch, codling moths | Percent ratio to sirup check | Total catch, blowflies | Percent ratio to sirup check |
|---|---|---|---|---|
| Formic acid | 8 | 4.91 | 9 | 1.35 |
| Acetic acid | 104 | 63.80 | 18 | 2.70 |
| Propionic acid | 32 | 19.63 | 111 | 16.67 |
| Butyric acid | 3 | 1.84 | 9 | 1.35 |
| Methyl alcohol | 8 | 4.91 | 7 | 1.05 |
| Ethyl alcohol | 17 | 10.43 | 102 | 15.32 |
| Propyl alcohol | 6 | 3.68 | 43 | 6.46 |
| Butyl alcohol | 4 | 2.45 | 0 | 0 |
| Methyl formate | 6 | 3.68 | 0 | 0 |
| Ethyl acetate | 3 | 1.84 | 9 | 1.35 |
| Propyl propionate | 5 | 3.02 | 11 | 1.65 |
| Butyl butyrate | 9 | 5.52 | 0 | 0 |
| Cane sirup check | 163 | 100.00 | 666 | 100.00 |

TABLE 4.--COMPARISON OF CANE SIRUP AND ACETIC ACID BAITS, SAN JUAN COUNTY, JULY 31 TO SEPTEMBER 1, 1941

| Bait | Dates and numbers of moths caught | | | | | | | | | Total catch | Average per trap per day | Percentage ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8/4 | 8/7 | 8/11 | 8/14 | 8/19 | 8/21 | 8/25 | 8/28 | 9/1 | | | |
| Cane sirup, 1-10+ 0.2% sodium benzoate | 24 | 16 | 9 | 14 | 6 | 11* | 11 | 3 | 3 | 97 | 0.64 | 100.0 |
| Glacial acetic acid, 1% in 20 cc. of gum tragacanth-glycerine emulsifier | 71 | 11 | 2* | 27 | 4** | 21 | 21** | 40 | 15 | 212 | 1.70 | 218.5 |

*Jars refilled with fresh cane sirup bait.
**Acetic acid added to bait.

In the comparisons of amino acids, these were first tested at 0.2-percent concentration in a bait consisting of distilled water containing 1 percent each of commercial dextrose and sucrose. To insure rapid fermentation these baits were inoculated with a mixed culture of the 2 species of bacteria previously demonstrated to increase the attractiveness of fermenting carbohydrates (i.e., *Aerobacillus polymyxa* and *Aerobacter aerogenes* (i.e.,48th and 49th Annual Reports). Since these comparisons were conducted during the interim between the flight periods of the first- and second-generation moths, a constant population was insured by placing the baits in the large screen cage described in the 48th Annual Report and supplying newly emerged moths from pupae which had been kept over winter in the refrigeration plant of the College Dairy Department. Table 5 presents the catches secured in this manner. It may be seen that proline, tryptone, and glycocoll (Merck) were the most attractive of the amino acids tested, all of them increasing the catches approximately 100 percent in comparison with those of the dextrose check. Tyrosin, creatine, leucine, and aspartic acid were also fairly attractive. None of the latter were as good, however, as the standard cane sirup bait consisting of 10 percent Brer-Rabbit sirup inoculated with the same species of bacteria as used in the other baits.

TABLE 5.--COMPARISON OF AMINO ACID-SUGAR BAITS IN FIELD CAGE, STATE COLLEGE, JUNE 16 TO JULY 4, 1941

| Amino acid in bait | Number of moths per trap | Percentage of total catch | Percentage ratio to sucrose-dextrose check |
|---|---|---|---|
| Proline | 72 | 7.46 | 218.1 |
| Tryptone | 67 | 6.95 | 203.0 |
| Glycocoll (Merck) | 65 | 6.74 | 196.9 |
| Tyrosin | 58 | 6.01 | 175.7 |
| Creatine | 55 | 5.70 | 166.6 |
| Leucine | 53 | 5.49 | 160.6 |
| Aspartic acid | 49 | 5.08 | 148.4 |
| Valine | 48 | 4.97 | 145.4 |
| Cystine | 48 | 4.97 | 145.4 |
| Glycollic acid | 43 | 4.46 | 130.3 |
| Glycocoll (Hauf) | 40 | 4.14 | 121.2 |
| Phenylalanine | 38 | 3.94 | 115.1 |
| Isoleucine | 35 | 3.63 | 106.0 |
| Arginine | 32 | 3.31 | 96.9 |
| Serine | 32 | 3.31 | 96.9 |
| Histidine | 31 | 3.21 | 93.9 |
| Alanine | 26 | 2.69 | 78.7 |
| Glutamic acid | 23 | 2.38 | 69.6 |
| Sucrose-dextrose check | 33 | 3.42 | 100.0 |
| Cane sirup check | 116 | 12.03 | 351.5 |

Later in the season the 7 amino acids which indicated highest attractiveness in the cage experiment were tested in the field, using 0.25 percent concentrations in each of the following: commercial cane sugar or brown sugar, at the rate of 1 pound per gallon of water, and cane sirup at the rate of 1 part in 10 parts of water. Sterile distilled water was used in making up the baits, and the baits were inoculated with the same bacteria as used in the previous test. The effectiveness of each amino acid was rated on the basis of its increase over the form of carbonhydrate with which it was compared (Table 6). Glycocoll (Merck) and proline increased the catch of both cane sirup and cane sugar bait; all of the amino acids except creatine increased the attractiveness of sucrose bait; tryptone and leucine increased the attractiveness of brown-sugar bait. Owing to the relatively high cost of most of these amino acids, further investigations are in progress to determine the effectiveness of some of the crude protein sources of these amino acids which are readily available for use by orchardists who find it practical to operate bait traps as indicators for forecasting their spraying programs.

TABLE 6.--FIELD COMPARISON OF AMINO ACIDS IN COMBINATION WITH SUGAR AND SIRUP BAITS, STATE COLLEGE, JULY 23 TO AUGUST 6, 1941.

| | Glycocoll (Merck) | Proline | Tryptone | Leucine | Aspartic acid | Tyrosine | Creatine | Check |
|---|---|---|---|---|---|---|---|---|
| | | | | Cane-sugar series | | | | |
| Average number of moths per trap | 11.0 | 9.0 | 3.0 | 5.0 | 6.0 | 4.0 | 1.0 | 1.6 |
| Percentage catch of the series | 27.05 | 22.13 | 7.38 | 12.31 | 14.75 | 9.85 | 2.46 | 3.94 |
| Percentage ratio to series check | 687 | 500 | 187 | 312 | 375 | 250 | 62 | 100 |
| | | | | Brown-sugar series | | | | |
| Average number of moths per trap | 9.0 | 10.0 | 14.0 | 14.0 | 6.0 | 2.0 | 9.0 | 11.6 |
| Percentage catch of the series | 11.89 | 13.21 | 18.50 | 18.50 | 7.93 | 2.64 | 11.89 | 15.41 |
| Percentage ratio to series check | 77 | 85 | 120 | 120 | 51 | 17 | 77 | 100 |
| | | | | Cane-sirup series | | | | |
| Average number per trap | 25.0 | 20.0 | 11.0 | 10.0 | 9.0 | 8.0 | 7.0 | 12.2 |
| Percentage catch of the series | 24.46 | 19.56 | 10.76 | 9.78 | 8.80 | 7.82 | 6.84 | 11.93 |
| Percentage ratio to series check | 205 | 163 | 90 | 81 | 73 | 65 | 57 | 100 |

## NEW YORK

S. W. Harman, New York State Agricultural Experiment Station, Geneva

Seasonal conditions and codling moth abundance. The season of 1942 was very favorable for codling moth activity in western New York. Moths first appeared in the orchards by the middle of May and the first eggs hatched early in June. McIntosh apples were harvested in mid-September and it was not uncommon to find fresh codling moth entrances at that time. Timely and thoro spraying was essential for the production of worm-free fruit.

Control by insecticides. Although lead arsenate continues as the standard insecticide for combating the codling moth, considerable quantities of nicotine have been employed successfully by fruit growers as a lead arsenate substitute.

Experimental effort with a number of organic materials during the past several years has indicated that ground derris, used in combination with a small amount of summer oil, is very effective as a control for the codling moth. On the other hand, rotenone extracts have not proved as efficient as the ground root. Experience with pyrethrum sprays has not been especially promising.

Data from field tests made in a McIntosh orchard this past season are presented in the following table.

Codling Moth Control, Geneva, New York, 1942

| Treatment used in 7 cover sprays Amounts per 100 gallons | Stings on 100 apples | Worms in 100 apples |
|---|---|---|
| 1. Black Leaf 155, 3 lbs.; Oil 875, 1 qt. | 3.8 | 1.5 |
| 2. Black Leaf 155, 1 1/2 lbs.; Oil 875, 1 1/2 qts. | 2.2 | 2.4 |
| 3. Black Leaf 40, 3/4 pt.; Oil 875, 1 1/2 qts. | 4.5 | 3.3 |
| 4. Pyrethrum flowers[1] 2 lbs.; Oil 875, 1 qt. | 16.3 | 20.8 |
| 5. Prethrum flowers, 4 lbs.; Oil 875, 1 qt. | 13.8 | 11.3 |
| 6. Pyrocide 20, 1 pt.; Oil 875, 1 qt. | 17.0 | 17.5 |
| 7. Pyrocide 20, 1 qt.; Oil 875, 1 qt. | 6.3 | 8.0 |
| 8. Derris[2], 2 1/2 lbs.; Oil 875, 1 qt. | 2.2 | 1.0 |
| 9. Lethane 60-derris conc.[3], 2 lbs. | 19.8 | 32.3 |
| 10. Lethane 60-derris conc., 2 lbs.; Oil 875, 1 qt. | 5.5 | 11.3 |
| 11. Lead arsenate, 3 lbs. | 23.4 | 1.1 |
| 12. Checks -- average | 24.1 | 126.6 |

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[1] Pyrethrum flowers contained 1.3 percent pyrethrins.

[2] Derris tested 5.7 percent rotenone.

[3] A Rohm & Haas product.

NEW YORK

Irene D. Dobroscky, New Paltz

## Dusting Orchards With Natural Cryolite for Codling Moth Control.

Realizing that there would be a labor shortage, it was decided that a dusting program was in order. During the season of 1942, apple orchards were dusted; some with Kryocide and sulphur, and others with lead arsenate and sulphur, both mixtures at the rate of 20% to 80% respectively. Kryocide is the trade name for natural cryolite (sodium fluoaluminate), which is now milled to a fineness of 5 microns. In previous years, Kryocide had been tested as an orchard spray with satisfactory results, so this year it was used as a dust for the first time.

The delayed Dormant and the Pre-pink sprays were, as usual, made up of lead arsenate and lime-sulphur. From then on, during May, June and July, the orchards were dusted. Since the toxicity of cryolite is destroyed by lime, dusting sulphur alone was used as the diluent.

Two blocks of McIntosh trees were used in the experiments. Each tree received about one and one half pounds of dust at each application, and there were eight applications in all. During May, which was a rainy month, the dusts were applied for the control of the scab fungus; during June and July for the control of the first and second brood codling moth.

At harvest time, random samples of 100 apples were taken from twenty trees. The data showed that the average number of stings and entries of codling moth in apples dusted with lead arsenate was 14.6%; in the Kryocide samples the number was 6.7%. The control of apple scab in the first group was 0.8%, in the second 2.8%.

The fact that the lead arsenate block did not show up as well as the Kryocide block may have been due in part, to the fact that these trees were nearer to the packing shed and other farm buildings, which have some relation to the incidence of codling moth. Next year it is planned to reverse the treatment of these two blocks of trees.

No injury to fruit or foliage was observed in these experiments.

In three hours, it was possible to dust as many trees as it normally took three days to spray. Such difficult problems as water shortage; the time it takes to fill a spray tank; the weight of the spray rig causing traction trouble on wet ground or on steep hillsides; innumerable mechanical troubles with the spray rig; all such problems were eliminated by the use of a duster.

## OHIO

C. R. Cutright, Ohio Agricultural Experiment Station, Wooster.

### I. Seasonal conditions and codling moth abundance.

Temperatures in Ohio for the month of April 1942 averaged over 5 degrees above normal. May was almost 3 degrees above, and June nearly 2 degrees. Due to these excess temperatures, moths emerged from 10 to 12 days earlier than normal and their activities were greatly accelerated. Fovorable conditions for the codling moth also existed during July, August, and early September. As a result of these conditions and the lengthened period of codling moth activity, infestations in Ohio were generally the worst since 1934. This was especially true in northwestern, southern, and central Ohio. Northeastern Ohio, as usual, had little trouble with the codling moth. The following summarized table indicates codling moth activity at three points in Ohio.

### II. Summary of Codling Moth Biology, Ohio, 1942

| | Wooster (N.E. Central) | Waterville (N.W.) | Lorain (North.) |
|---|---|---|---|
| | Spring-brood Moth Emergence | | |
| 1st moth | May 2 | May 9 | May 11 |
| 50% | May 14 | May 19 | May 30 |
| Last moth | June 15 | June 22 | July 2 |
| | Summer-brood Moth Emergence | | |
| 1st moth | July 13 | July 15 | July 17 |
| 50% | July 28 | Aug. 5 | Aug. 11 |
| Last moth | Aug. 26 | Sept. 5 | Sept. 3 |
| | 1st Larvae under Bands | | |
| | June 24 | June 26 (estimated) | July 3 |

### III. Control experiments.

(a) Field control experiments were conducted in heavily infested orchards at Lorain and Waterville, Ohio. Thirty-four different spray schedules were tested as to their efficiency in worm control and their effect on fruits and foliage. Single-tree plots with 5 replicates, laid out according to the randomized block system, were used.

(b) In both orchards, Jonathan was the test variety. All test trees were fully grown and carried a commercial crop of fruit.

(c) On some plots where no fungicide was used after calyx, such as oil--nicotine schedules, some scab developed. However, where care was used in applying the early sprays, no trouble from this source occurred. In all cases where zinc sulfate was combined with the spray, excellent foliage resulted,

(d) In orchards receiving from 5 to 7 cover sprays of lead arsenate, residues ranged from .170 to .250 gr. of lead per lb. Such residues were easily removed by washing.

A. Control by insecticides.

(1) A schedule of lead arsenate, lime, zinc sulfate plus summer oil in the 2nd, 3rd, and 4th covers (see committee report for 1941) continued to give best results when considered from the standpoint of worm control, cost, and foliage condition. As suggested by the Committee on Supply of Insecticides, two schedules of lead arsenate at 2 pounds per 100 gallons instead of the usual 3 were tested at two points in Ohio. Both were definitely inferior to the 3-pound dosage.

(a) Several schedules carried the sticker "Alcote" (du Pont) in various combinations. Its use increased the residue load at harvest time but did not aid in codling moth control.

(4) (a) Fixed nicotine in combination with summer oil in a schedule of 6 cover sprays gave control comparable to lead arsenate. Excellent control was obtained with B. L. 155 (14%) 2 pounds plus 1/2 gallon of summer oil in a schedule of 6 cover sprays preceded by a calyx and 1st cover of lead arsenate.

B. L. 155 (micronized) seemed slightly superior to B. L. 155 (regular) used both with and without summer oil.

Schedules of lead arsenate reinforced with fixed nicotine in the 2nd, 3rd, and 4th covers were quite efficient as in former years. Such a schedule used with the sticker "Alcote" gave excellent results.

(b) Several formulations of Phenothiazine were tried but all were ineffective against worms. Stings were not numerous. Foliage and the finish of the fruit was good.

B. In view of the labor shortage for sanitary work in orchards, a test of banding 30 unscraped trees (except for the area under and adjoining the band) against 30 fully scraped trees was conducted. Approximately 20 larvae were taken on the scraped trees for every one collected on the unscraped.

IV. Ohio growers experienced little difficulty with shortages of either spray material or machinery in 1942.

## OREGON

L. G. Gentner, Southern Oregon Branch Experiment Station, Talent.

## I. Seasonal Conditions and Status of Codling Moth Infestation.

The first moths were caught in bait pans on May 5. (a few moths were caught at Central Point by the county agent on April 18, 19, and 20, the only nights in April on which the temperature at sunset was 60 degrees or above, but apparently no eggs were deposited). There were only 10 nights in May with temperatures at sunset 60 degrees or higher. Even during the first part of June temperatures were abnormally low. This resulted in a very light flight of spring-brood moths. In the commercial apple orchard where records were kept, the peak catch of spring-brood moths did not occur until June 19, with an average catch of only 31 moths per pan as compared to 122 in 1941 and 391 in 1942. The period of highest moth catch of the first-brood moths occurred August 5 to 10, with an average of only 25 moths per pan per night. The bait pan placed in the same tree as in previous seasons captured only 635 moths as compared to 1,430 in 1941 and 4,212 in 1940.

A calyx and six cover sprays were recommended for apple and late pear trees, and a calyx and five cover sprays for Bartlett trees. The timing of these sprays was based on moth catches in bait pans, supplemented by extensive field and insectary observations and thermographic records of temperatures at sunset.

## III. Results of Control Experiments.

Tests for codling moth control were carried on in the same commercial orchard as in previous years. The trees were 37 years old, smaller than the average for that age, and not uniform in size. All plots received a calyx and five cover sprays, except plot 9, which received a calyx and only four cover sprays. Dates of application were as follows: calyx, April 25; 1st cover, June 1; 2nd cover, June 12; 3rd cover, June 30; 4th cover, July 25; 5th cover, August 19; except plot 9 -- 1st cover, June 1; 2nd cover, June 18; 3rd cover, July 10; 4th cover, August 19.

a. Each plot consisted of eight trees -- four random replicates of two trees each. All of the fruit from the tree and on the ground from all trees in each plot was examined for worm injury. Sprays were applied with a Bean portable sprayer at a pressure of 400 to 450 pounds at the pump, using two leads of hose, spray guns, discs with 7/64 inch openings. Eleven to twelve gallons of spray were used per tree per application.

b. Because the early part of the season was cool with sunset temperatures on many days too low for codling moth activities, attack by first-brood larvae was comparatively light. The codling moth development was abnormally late, but the fruit development was also about a month late, so that fruit which was not regularly sprayed suffered considerable worm attack later in the season.

## Control in Commercial Bartlett Orchard

| Plot and Material (1) | % Calyx Injured | % Side Injured | % Stung | Total % Wormy Stung | Av. No. Fruits Per Tree |
|---|---|---|---|---|---|
| # 1 - Lead arsenate-77-stove oil (2) Brand 4, all sprays. (Check) | 1.5 | 2.7 | 0.2 | 4.4 | 826 |
| # 2 - Lead arsenate-77-stove oil Brand 6, all sprays | 0.8 | 1.6 | 0.2 | 2.6 | 1,074 |
| # 3 - Lead arsenate-77-stove oil Brand 3a, all sprays | 0.9 | 1.5 | 0.2 | 2.6 | 986 |
| # 4 - Lead arsenate-MF-stove oil Brand 3, all sprays | 0.9 | 1.6 | 0.2 | 2.7 | 908 |
| # 5 - Lead arsenate-77-stove oil Brand 2, all sprays | 1.6 | 2.9 | 0.1 | 4.6 | 979 |
| # 6 - Lead ars.-77- st. oil in calyx; Lead ars.-Alkote in covers | 1.1 | 2.2 | 0.1 | 3.4 | 731 |
| # 7 - Lead arsenate-77-stove oil 4 lbs. all sprays | 0.4 | 1.4 | 0.1 | 1.9 | 1,212 |
| # 8 - Lead ars.-Fluxit in calyx Lead ars.-77-st. oil in covers | 0.9 | 1.9 | 0.3 | 3.1 | 934 |
| # 9 - Lead arsenate-77-stove oil 4 covers only | 2.0 | 5.0 | 0.2 | 7.2 | 855 |
| #10 - Lead ars.-77-st. oil in calyx; Lead ars.-Z-1 in covers | 1.3 | 3.2 | 0.3 | 4.8 | 982 |
| #11 - Lead ars.77-st. oil in c, 1, 2; Genicide-Genifilm-kerosene in 3, 4, 5. | 1.1 | 3.6 | 0.2 | 4.9 | 887 |
| #12 - Lead ars.-77-st. oil in c, 1, 2; Micron. phenothiazine in stove oil emulsion in 3,4,5. (3) | 0.9 | 1.5 | 0.1 | 2.5 | 875 |

(1) Lead arsenate was used at the rate of 3 pounds in 100 gallons, except in plot 7, 4 pounds; Colloidal 77, Multi-Film, and Fluxit 1/4 pound (1/8 pound in fifth cover); stove oil, 1 quart; Z-1, 1/3 pound; Alkote, 3/4 pint; Genicide, 1 1/2 pounds; Genifilm A, 6 ounces; Genifilm B, 2 ounces; kerosene, 3 pints; micronized phenothizine, 2 pounds; stove oil emulsion, 2 quarts.

(2) Brand 4 lead arsenate was used wherever the brand is not given.

(3) Stove oil emulsion for phenothiazine was made up according to the following formula: 56 cubic centimeters of 28% ammonium hydrate, 1 gallon water, 6 ounces casein, 3 gallons stove oil.

c. There was some spotting or blotching on a small percent of the fruit in the case of practically all materials used, because of sudden, extremely hot weather the last of June, following a prolonged period of abnormally cool, cloudy weather.

d. No difficulty was experienced in removing the spray residue to within the tolerance at harvest time, when recommended spray schedules were followed.

Spray deposits varied somewhat with the type of materials used. Deposit analyses were made by R. H. Robinson, Chemist, Oregon Experiment Station, Corvallis. Six pears were carefully chosen from trees sprayed with each treatment and 232 square centimeters were cut from the surface in disc form and the arsenic determined on this area by the bromate method.

### Spray Deposits on Pears Before and After Fifth Cover Spray

| Plot and Material | Type of Deposit | Before 5th Cover | After 5th Cover |
|---|---|---|---|
| | | Micrograms $As_2O_3$ | per sq. cm. |
| #1 - Brand 4,<br>77,st.o. | Before: Good even coat.<br>After: Excellent, heavy even deposit. | 14.4 | 26.8 |
| #2 - Brand 6,<br>77,st.o. | Before: Good even coat, some blotch spots.<br>After: Excellent, heavy deposit | 15.2 | 22.3 |
| #3 - Brand 3a,<br>77,st.o. | Before: Good even coat, some blotch spots.<br>After: Excellent, heavy deposit | 17.1 | 24.4 |
| #4 - Brand 3,<br>MF,st.o. | Before: Good even coat, some blotch spots.<br>After: Excellent, heavy deposit | 15.5 | 23.6 |
| #5 - Brand 2,<br>77,st.o. | Before: Good even coat.<br>After: Excellent, heavy deposit. | 12.0 | 21.0 |
| #6 - Brand 4,<br>Alkote | Before: Good even coat.<br>After: Excellent, heavy deposit. | 13.7 | 19.8 |
| #7 - 4# l.a.,<br>77,st.o. | Before: Good even coat, blotch spots.<br>After: Excellent, heavy deposit, some spots. | 15.5 | 28.8 |
| #10- Brand 4,<br>Z-1 | Before: Good even coat.<br>After: Excellent, heavy deposit. | 8.5 | 17.6 |
| #12- Micronized phenothiazine | | 5.3 | 12.1 |

A. Control by Insecticides.

(1) Lead Arsenate. This insecticide must still be considered our most effective material for codling moth control. Because of recent investigations, manufacturers of this material have given special attention to their products. As a result, most brands of lead arsenate used in this section give good control. However, where codling moth control is a problem, it is necessary to add materials to improve the deposit and coverage in order to obtain best results. The recommended dosage is 3 pounds in 100 gallons, however, in 1942 the cleanest fruit was obtained where a dosage of 4 pounds was used (plot 7). Under Rogue River Valley conditions a calyx and five cover sprays is normally the number that must be applied to Bartlett pear trees to obtain control. Where only four cover sprays were used, the intervals between sprays being lengthened, noticeably more wormy fruit was harvested (plot 9).

(a). Addition of deposit-builders and other accessory materials. The addition of 1/4 pound of Colloidal 77 or Multi-Film, dry deposit-builders, and 1 quart of stove oil or kerosene produces a flocculation in the tank and when the mixture hits the trees, most of the lead arsenate remains and the water runs off. If the spray nozzle is moved slowly, a heavy deposit results. With good, thorough spraying a rather uniform, granular, film-type of cover results, which weathers quite well and gives satisfactory control (plots 1.2,3,5). The addition of 3/4 pint of Alkote, a paste-type preparation, resulted in a good even cover which gave effective control (plot 6). The use of 1/3 pound Z-1, a dry deposit-builder for use without oil, resulted in somewhat inferior control because of lighter deposit (plot 10) (see table of deposit analyses).

(4) Organic materials.

(b) Micronized phenothiazine was substituted for lead arsenate in the last three cover sprays, at the rate of 2 pounds per 100 gallons, beaten into 2 quarts of stove oil emulsion and then added to the tank. In spite of a rather low deposit, the control was equally as good as the best control obtained with 3 pounds of lead arsenate, deposit-builder, and stove oil (plot 12).

(c) Xanthone was substituted for lead arsenate in the last three cover sprays. The commercial preparation called Genicide was applied at the rate of 1 1/2 pounds per 100 gallons, with 6 ounces of Genifilm A, 3 pints of kerosene, 2 ounces of Genifilm B (plot 11). The control was somewhat inferior to that obtained with 3 pounds of lead arsenate, deposit builder, and stove oil but better than in previous years. This indicates that an improvement in the type and amount of coverage will improve control.

## IV. Experience of Growers in Obtaining Insecticides and Spray Equipment.

In general, the fruit growers of the Rogue River Valley were able to obtain the necessary spray equipment and parts, although in some cases there was delay in obtaining some repair parts. Insecticides were obtainable in sufficient quantities to meet the needs of the growers, although there was some difficulty in obtaining sufficient nicotine sulphate.

PENNSYLVANIA

H. M. Steiner, Pennsylvania Agricultural Experiment Station, State College. In the absence of H. N. Worthley on military leave.

Seasonal conditions and codling moth abundance: Warm weather in April and early May advanced both tree and codling moth development about one week earlier than in 1941. The temperature for the remainder of the season departed only a fraction of a degree from the average for the locality (Adams County) during each month of the growing season. Wet weather, beginning May 15, together with many cloudy days and heavy fog often interferred with orchard work.

The local crop was heavy and fruits were large. It was an off-year for approximately one-fourth of the orchards but the southern Pennsylvania orchards produced about 40% more than average in spite of an approximate loss of 8% to rosy aphis. Orchardists who had applied 3 cover sprays by June 12 followed by one or two additional sprays generally obtained much better codling moth control than in previous years with losses mostly less than 5%. One to 4 blocks in each of 20 nearby orchards known as "codling moth sites" contained infestations averaging 10 worms per 100 apples in counts taken in early September and these crops ranged from 0 to 105 worms per 100 apples.

Emergence of spring brood moths from caged material began May 2, was 50% complete by May 28 and 99.9% complete on June 27. There were no sharp peaks in emergence. Emergence of first brood moths began July 7, was 50% complete by July 31 and complete on September 4 with a peak of emergence on August 1.

Moths were taken in bait pails from May 4 to September 11. Catches of 100 or more moths were taken only on May 12, 14, 18 and 27 from 5 double traps operated in one orchard throughout the season. Baits changed alternately at 10 day intervals were frequently diluted by rain and failed to indicate moth activity during cloudy weather, especially in early June.

Early eggs were numerous on fruits and foliage by May 18 but first entries were not observed until May 23. Eggs in the black-spot stage on May 18 failed to hatch. Larvae were taken in bands from June 19 to October 25 although the fruit was harvested before Oct. 10. Codling moth attack occurred later than usual continuing until late September. In the main test orchard, approximately 25% of the larvae taken in bands from August 1 to October 25 were oriental fruit moth larvae.

Table 1. Moths captured in 5 double quart traps. Test Block, Arendtsville, Pa. 1942.

| Month: | Total Males: | Total Females: | Total Moths: |
|---|---|---|---|
| May | 850 | 269 | 1119 |
| June | 60 | 96 | 156 |
| July | 99 | 147 | 246 |
| August | 199 | 204 | 403 |
| September | 22 | 20 | 42 |
| Total | 1230 | 736 | 1966 |

The time of codling moth attack was followed by frequent counts on 4 unsprayed trees in a well sprayed orchard. At each date of counting, 100 fruits in the top and 100 fruits on the lower branches of each tree were scored for codling moth injuries. Injuries on drop fruits were counted on each date. At harvest, the number of injuries per 100 total fruits was calculated back for each count date. The counts are summarized in Table 2.

Table 2. Codling moth and oriental fruit moth injuries with rainfall between dates of counting.

| Time interval: | Rainfall (inches) between counts: | Accumulated injuries per 100 fruits to last date: |
|---|---|---|
| May 15-23 | 6.74 | 0.1 |
| May 23-30 | Trace | 4 |
| May 30-June 6 | 2.44 | 19 |
| June 6-12 | 0.91 | 33 |
| June 12-20 | 0.35 | 62 |
| June 20-28 | 2.91 | 75 |
| June 28-July 6 | 0.20 | 95 |
| July 6-13 | 1.19 | 100 |
| July 12-20 | 0.33 | 100 |
| July 20-28 | 4.98 | 105 |
| July 28-Aug. 4 | 0.54 | 116 |
| Aug. 4-10 | 2.05 | 123 |
| Aug. 10-15 | 2.26 | 128 |
| Aug. 15-24 | 1.40 | 138 |
| Aug. 24-Sept. 2 | 0.11 | 146 |
| Sept. 2-11 | 0.56 | 150 |
| Sept. 11-22 | 0.37 | 161 |
| Sept. 22- Harvest | 2.86 | 166 |

Field experiments: A well pruned block of mature Stayman trees was used in spray tests of 1942. The trees had suffered from the intense drought of 1941 when the fruit was more than 50% wormy after 5 poorly timed lead arsenate cover sprays had been applied. There was a large carry-over of worms to 1942. The set of fruit was below average for the block. Twelve treatments differing in schedules or materials were used. Treatments were replicated 5 times on single tree plots. Forty of the weaker trees and the border rows were sprayed with the schedule and materials used in treatment No. 9 of table 3. One tree at each corner of the block in border rows received no spray after petal-fall.

The block received a petal-fall spray on May 2 and a first cover spray on May 18 consisting of 4 oz. manganese sulfate (80%), 4 oz. Soya flour and 3 lbs. lead arsenate mixed dry and then pasted with 3 qts. water before adding to 100 gallons of a 1-75 liquid lime sulfur solution. Differential treatments began with the second cover spray.

Table 3. Treatments applied to the experimental block, Arendtsville, Pa.*

| Treatment No. | 2nd cover: May 30 | 3rd cover: June 10 | 4th cover: June 23 | 5th and 6th covers: July 22 | Aug. 3 |
|---|---|---|---|---|---|
| 1 | LA 3#, Lime 3# | LA 3#, Bordo | --- | --- | --- |
| 4 | LA 3#, DO 1 qt. | LA 3#, DO 1 qt. Bordo | --- | --- | --- |
| 6 | LA 3#, Orthex 1 qt. | LA 3#, Orthex 1 pt., Bordo | --- | --- | --- |
| 8 | As 6 | As 6 | Bordo | --- | --- |
| 2 | As 1 | As 1 | --- | LA 3#, Bordo | |
| 3 | As 1 | As 1 | --- | SO 3 qt, NS 3/4 pt., Bordo | |
| 5 | As 4 | As 4 | --- | As 3 | |
| 7 | As 6 | As 6 | --- | As 3 | |
| 9 | Tank-mix nicotine bentonite | | LA 3#, Orthex 1 Pt., Bordo | As 3 | |
| 10 | As 9 | As 9 | As 9 | --- | --- |
| 12 | As 9 | As 9 | SO 3 qt. NS 3/4 pt., Bordo | As 3 | |
| 11 | Factory conditioned micronized phenothiazine in 5 covers at two pounds per 100 gallons of spray. | | | | |

* Bordo- Bordeaux mixture used at 1-5-100
LA-Corona acid lead arsenate
SO-Orthol K Summer oil emulsion
DO- a 66.7% tank-mixed stock emulsion of petroleum oil emulsified with Goulac - Gulf paraffin # 372 base.
Tank-mix nicotine bentonite as developed by the Bur. of Ent. & P.Q.

The second cover sprays were immediately followed by high temperatures for two days (92° F. max.) at high humidities and then 4 days of dense fog and wet weather. Oil-sulfur injury developed wherever any form of oil was used on weak branches. It caused a thinning of fruits on treatments 4 and 5 and a slight reduction in set on treatments 6-7 and 3. No further injury developed at or following the third cover spray except a negligible amount of leaf spot associated with arsenical injury.

Counts on trees treated with materials listed in table 3 are given in table 4.

Table 4. Results obtained on treatments listed in table 3.

| Treatment No. | Total fruits per tree: | % Clean: | Worms per 100 fruits: 6/23* | 7/15 | Harvest | Total Injuries per 100 fruits: 6/23* | 7/15: | Harvest | % leaves showing any arsenical injury: |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1451 | 48 | 1.9 | 2.1 | 36.8 | 24 | 45 | 113 | 4 |
| 4 | 1396 | 61 | 1.1 | 0.7 | 22.6 | 15 | 28 | 78 | 9 |
| 6 | 1258 | 54 | 1.5 | 1.6 | 30.2 | 22 | 45 | 103 | 8 |
| 8 | 1561 | 56 | --- | 1.4 | 25.2 | -- | 41 | 87 | 4 |
| 2 | 1610 | 57 | --- | 1.7 | 7.0 | -- | 50 | 76 | 3 |
| 3 | 1562 | 60 | --- | 2.2 | 13.2 | -- | 45 | 66 | 2 |
| 5 | 1238 | 70 | --- | 1.1 | 9.8 | -- | 56 | 52 | 9 |
| 7 | 1504 | 66 | --- | 1.1 | 11.4 | -- | 45 | 59 | 7 |
| 9 | 1680 | 62 | 0.3 | 2.4 | 20.0 | 11 | 24 | 66 | 1 |
| 10 | 1372 | 52 | --- | 1.9 | 33.6 | -- | 25 | 88 | 2 |
| 12 | 1340 | 62 | 0.2 | 2.2 | 25.6 | 11 | 30 | 63 | 2 |
| 11 | 1486 | 56 | 2.4 | 5.6 | 48.8 | 13 | 27 | 76 | 3 |
| No spray after petal-fall (Ave. of 4 trees at corners of block:) | | | | | | | | | |
| 0 | 2201 | 28 | 21.8 | 28.0 | 88.4 | 71 | 100 | 166 | 3 |

* Counts of June 23 show effects of first 3 cover sprays to that date.

The early drop caused by oil-sulfur injury on treatments 4 and 5 introduces a large error in the calculations where the total crop is considered as above.

Tests in large blocks: Large block tests of two spray schedules in the hands of growers were followed in 3 Adams County, Pa. orchards. Two blocks of 50 or more trees were sprayed in each orchard with these schedules.

Table 5. Schedules used in large block tests. 1942.

| | Schedule No. 1 | Schedule No. 2 |
|---|---|---|
| Petal-fall: May 1-3<br>&<br>First cover: May 15-18 | Lead arsenate 5 lbs.<br>Manganese sulfate 4 oz.<br>Soya flour 4 oz.<br>Liquid lime sulfur 1.3 gals. | Lead arsenate 3 lbs.<br>Manganese sulfate 4 oz.<br>Soya flour 4 oz.<br>Liquid lime sulfur 1.3 gals. |
| Second cover: May 25-28 | Nicotine sulfate 1 pt.<br>Wyoming bentonite .5 lbs.<br>Soy bean oil 1 qt. | Lead arsenate 5 lbs.<br>Orthex 1 qt. |
| Third cover: June 8-12 | As above | Lead arsenate 3 lbs.<br>Orthex 1 pt.<br>1-5-100 Bordo |

Table 5 - continued

| | Schedule No. 1 | Schedule No. 2 |
|---|---|---|
| Fourth cover: June 22-25 | As in 3rd cov. of Sch. 2 | Lead arsenate 3 lbs.<br>Orthox 1 pt.<br>1-5-100 Bordo |
| Fifth cover: July 23-25 omitted in one block: | As in 3rd cov. of Sch. 2 | As above |

Table 6: Results of large block tests with schedules of table 5.

| Schedule | Total fruits per tree: | % Clean: | Worms per 100 fruits 7/14 | | Total injuries per 100 fruits: 7/14: | Harvest: | Number per 100 leaves: Leaf-miners | Leaf-hoppers |
|---|---|---|---|---|---|---|---|---|
| | | | 7/14 | Harvest | 7/14: | Harvest: | Leaf-miners | Leaf-hoppers |
| Orchard A. Variety-McIntosh, first four covers only: | | | | | | | | |
| 1 | 2930 | 91 | 0.4 | 3.0 | 4 | 12 | 0.3 | 42 |
| 2 | 2627 | 88 | 0.1 | 2.6 | 7 | 15 | 13.0 | 170 |
| Orchard B. Variety-Stayman, five covers: | | | | | | | | |
| 1 | 2434 | 75 | 0.1 | 6.5 | 12 | 39 | 0.2 | 5 |
| 2 | 1878 | 62 | 1.1 | 5.6 | 42 | 90 | 3.0 | 25 |
| Orchard C. Variety-Red Delicious, 5 covers with 1 pt. nicotine sulfate for leafhopper included in second cover spray: | | | | | | | | |
| 1 | 2768 | 85 | 0.5 | 2.9 | 11 | 21 | 0.8 | 6 |
| 2 | 2137 | 71 | 1.4 | 2.7 | 32 | 48 | 1.6 | 9 |

In Orchard A tentiform leafminers increased to 186 per 100 leaves by Oct. 12 on Schedule 2 and to only 5 per 100 leaves on Schedule 1. In orchard C, colonies of wooly aphis occurred on 22% of the growing points in Schedule 2 and on 3% of the growing points of schedule 1. The color of fruits on Schedule 2 was generally poorer than on Schedule 1.

## UTAH

C. J. Sorenson, Utah Agricultural Experiment Station, Logan

Winter survival here of codling moth in 1942 was 90 per cent or more. No temperatures last winter were sufficiently low to kill the hibernating larvae. A late spring snow storm and freezing temperatures destroyed most peach, apricot, and pear blossoms resulting in an abnormally low yield of these fruits. The apple crop was also relatively light in 1942. Hail storms caused slight ruptures in the epidermis of apples which afforded better avenues of entry for small codling moth larvae. These conditions, together with relaxed spraying, because of the light crop, resulted in the heaviest codling moth infestation ever before experienced in this state, about four times heavier than in 1941 and approximately three times greater than average.

Satisfactory control was obtained by a few growers who made thorough application of the following sprays:

A. For first-brood worms:
   (1) Calyx spray, consisting of 3 pounds of lead arsenate in 100 gallons of water.

   (2) Three cover sprays at 8 to 10 day intervals, consisting of 3 pounds lead arsenate plus three-fifths gallon of summer-type oil and one-fourth pound of a build-up material having various proprietary names with different insecticide manufacturers.

   The first cover spray was applied only after evidence of oviposition had been obtained.

B. For second-brood worms and applications made only after evidence of oviposition:
   (1) Two cover sprays, consisting of the same materials as used in first-brood cover sprays.

Growers who followed the foregoing spray program experienced some difficulty in removing spray residues within tolerance.

It was interesting, nevertheless, to note that adequate control was obtained even under the exceedingly unfavorable conditions and high intensity of infestation that prevailed here last season.

## VIRGINIA

M. L. Bobb, Piedmont Fruit Research Laboratory, Virginia Agricultural Experiment Station, Charlottesville

## I. Seasonal Conditions and Codling Moth Abundance.

Emergence of spring-brood codling moths began on April 26 and the peak of emergence occurred about May 6. The spring-brood emergence was larger than normal due to a large carry-over of overwintering larvae. Unfavorable weather conditions during the hatching period of the eggs aided in checking larval entries in the fruit. Numerous rains occurred during the growing season. Only a small third brood developed and little injury was caused to the fruit late in the season. The prospective winter carry-over is smaller than last year.

## III. Results of Control Experiments.

### B. Control by means other than spraying.

#### 1. Bait traps

Experiments on the use of bait traps as an aid in controlling the codling moth were made in the same orchard in which like tests were made in 1939, 1940 and 1941. A square block of 100 apple trees were selected in the center of the large orchard and a bait trap was suspended in the upper third of each tree. The traps were of the quart-tin-can type, and each was filled three-fourths full with a bait consisting of 1 part of stock syrup to 20 parts of water plus 1 cc of anethol per quart of bait solution. The traps were put up when spring brood moths began to appear and were continued in operation until early October. The bait was replenished every three or four weeks and the traps were emptied and refilled with fresh bait at the beginning of each brood of moth emergence.

Eight trees in the center of the baited block and two trees on each side of the baited block, five rows out in the unbaited sections were selected for fruit counts at harvest. All drop fruits after July 1 and all picked fruits from the count trees were examined for codling moth injury. The results are shown in the table below.

| Items | Picked and drop fruits | |
|---|---|---|
| | Baited | Not Baited |
| Total apples | 6636 | 7159 |
| Per cent clean | 74.1 | 57.5 |
| Per cent wormy | 2.9 | 7.4 |
| Per cent stung | 23.0 | 35.0 |
| Per cent increase in clean fruit | 16.6 | |

VIRGINIA

A. M. Woodside, Field Laboratory, Virginia Agricultural
Experiment Station, Staunton

I. The carryover of codling moths in Augusta County in the spring of 1942 was very heavy. Moths began to emerge on April 30, about a week earlier than the usual time. Temperatures during May, June and July were somewhat above normal, and the rainfall during much of this time was considerably below normal. On the whole the season, with the exception of the first half of August, was favorable to the development of the codling moth. Third-brood larvae began to enter fruits about the middle of August, resulting in considerable late infestation. Damage was heavier than usual, and the number of hibernating larvae is high.

II. Some apple trees were scraped in April and the uninjured codling moth larvae were collected and placed on the ground under a cage. About 45 percent of these larvae were able to pupate and emerge.

A few days before emergence began in the insectary a small lot of larvae and pupae were taken from the insectary and placed in a common storage. A few of the ventilators were opened. Moths began to emerge in the cage in this storage about the same time as in the insectary, but the last emergence in this cage was about two weeks after the last emergence in the insectary. Moths continued to emerge from the orchard crates stored in this storage for five weeks after emergence ceased in the insectary. The mean temperature in this room was about 30° F. lower than that outside.

The question of the value of collecting drop fruits in heavily infested orchards for the purpose of destroying the codling moth larvae they contain is sometimes raised. The drop fruits under eight apple trees were collected once a week during July, August, and September and the injured fruits and living worms counted. In July there were 663 drops, among which there were 211 wormy apples, but only three living worms. In August there were 1175 drops, 178 wormy fruits, and 23 living worms; in September there were 1996 drops, 264 wormy fruits, and 13 living worms. About 94 percent of the worms had left these fruits before they were picked up.

III. B. Larvae and adults of Tenebroides corticalis Melsh. were fairly common under burlap bands, but less so than in 1941. In two orchards these beetles destroyed about a third of the codling moth larvae that started cocoons.

A bait trap was placed in each of a block of 100 apple trees. This was the third year that these trees had been so baited. Total injuries by the codling moth were about 55 percent lower in the baited block than outside.

A brief experiment was conducted to determine the best methods of destroying codling moth larvae in fruits removed in thinning. Thirteen lots of 100 apples each were used, and the several lots were treated as shown in table 1. After the treatment the apples of each lot were cut open to determine how many larvae had been killed or had died in the fruits. Burying of the fruits under a foot of well tamped soil, submersion in oil-covered water, confining them with paradichlorobenzene, or dipping them for three minutes in boiling water were all efficient in killing the larvae.

Table 1. - Results of treating wormy apples to kill the worms, Staunton, Virginia, 1942

| Lot Number | Treatment | Number of worms Total | Number of worms Survived | Control percent |
|---|---|---|---|---|
| 1 & 13 | Kept in battery jar in insectary | 112 | 103 | -- |
| 2 | Kept in uncovered pit four weeks | 55 | 17 | 66 |
| 3 | Buried 6 inches for 4 weeks | 50 | 1 | 97 |
| 4 | Buried 12 inches for four weeks | 61 | 0 | 100 |
| 5 | Buried 6 inches with paradichlorobenzene for four weeks[1] | 47 | 00 | 100 |
| 6 | Buried 6 inches with straw for four weeks[2] | 52 | 0 | 100 |
| 7 | Kept in closed vessel with paradichlorobenzene[1] for four weeks | 62 | 0 | 100 |
| 8 | Submerged in water two weeks | 51 | 2 | 95 |
| 9 | Submerged in oil-covered water two weeks | 53 | 0 | 100 |
| 10 | Submerged in boiling water one minute[3] | 53 | 14 | 72 |
| 11 | Submerged in boiling water three minutes[3] | 53 | 0 | 100 |
| 12 | Submerged in boiling water five minutes[3] | 55 | 0 | 100 |

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[1] Paradichlorobenzene was used at the rate of one ounce per cubic foot.

[2] Straw was placed above and below the fruit. Some of the larvae cocooned in this straw, but the moths that emerged here could not have escaped.

[3] Period of submersion was counted from the time that the water started to boil again after the bag of apples was dropped in.

## VIRGINIA

W. S. Hough, Winchester Research Laboratory, Virginia Agricultural Experiment Station, Winchester.

The apple crop was one of the largest on record, and codling-moth injury was about normal, except in orchards where second brood sprays were omitted, it was above normal in severity.

Heavy rains through June promoted rapid growth of the fruit and made effective spraying difficult. Rainfall in July was below normal and in August above normal. The net effect on spray residue (as shown by several thousand analyses made by the State Department of Agriculture) was a marked reduction of the lead-arsenate deposit on the fruit at harvest time.

Results of our experimental tests are summarized in tables 1 and 2. Drops were examined twice a month from July 1 to harvest time. The results of these examinations are included with the results of random sampling of the tree fruit at harvest time in arriving at the percentage of injury recorded. The apples were picked in late September and early October.

Nicotine as used in 9 covers in plats 1 and 2 gave better control than any other schedule.

Substitution of cube powder for part of the nicotine (plats 3 and 4) did not improve effectiveness of the spray. Supplementing the regular amount of nicotine with cube powder and lowering the oil content of the sprays to 1 pint per 100 gallons reduced the effectiveness of the sprays, as shown in plats 5 and 6.

Genicide in second brood sprays, following lead arsenate in the first brood sprays, gave satisfactory control.

DX was added to lead arsenate in certain cover sprays (plat 9). In the second brood sprays the lead arsenate was reduced to 2 lbs. plus DX 1-1/2 pints. Results were satisfactory.

Lead arsenate, when used alone (plat 12), gave satisfactory control but defoliated the trees of the King David variety in September. Foliage injury on the Stayman variety was conspicuous but less severe. About 16 percent of the leaves showed 30 to 100 percent of the leaf area injured.

Correctives for arsenical injury, as used in plats 13-17, practically eliminated arsenical injury, and apparently did not alter the efficiency of lead arsenate on trees having similar exposure to codling-moth attack as the trees in plat 12. The King David trees in plats 13-16 and in 17A, 18A, and 19A were located in an area which was exposed to a very heavy codling-moth attack.

The addition of small amounts of dinitro-o-cyclohexylphenol and dinitro-o-cresol to lead arsenate did not improve codling moth control, but surprisingly enough, arsenical injury on the foliage was practically eliminated.

Plats (B-1), (B-2), (L), and (L-) have included the same trees (12 trees in duplicate for each variety in each plat) for the past three seasons, in order to observe the effect of the spray schedules on yield. Plat (B-1) Delicious produced more first grade fruit per tree during 1940 and 1942 than any of the other Delicious trees.

For King David variety Plats (B-1) and (L-) yielded the same average of number 1 fruit per tree in 1942, while in 1940 plat (B-2) produced the highest average. In 1941 the yield in all plats was too light for comparison.

For the past two seasons codling-moth larvae have been reared on apples without having access to the core. Absence of seeds from the diet resulted in reduction in size (weight) of the larvae, but their progeny have shown no weakness in ability to enter sprayed fruit.

Table 1.--Results of experiments at Winchester, Va.

Note: Lead arsenate 3 lbs. and wettable sulfur in calyx in all plats. Lead arsenate 4 lbs. in first cover in all plats except plat 11, 2 lbs.

| Plat No. | Spray program and amount of insecticide per 100 gal: 2nd-9th covers, Plats 1-6; 2nd-7th covers, Plats 7-24 | Variety | Percent Wormy | Percent Total injuries |
|---|---|---|---|---|
| 1. | Black leaf-155 1-1/2 lbs.,<br>Oil 2 quarts | Sta.<br>K.D. | 1.1<br>2.1 | 3.4<br>4.2 |
| 2. | 12% base nicotine 1-3/4 lbs.<br>Oil 2 quarts | Sta.<br>K.D. | 0.7<br>2.0 | 5.3<br>5.5 |
| 3. | Black leaf-155 3/4 lbs.<br>Cube powder 3/4 lb.<br>Oil 2 quarts | Sta.<br>K.D. | 2.8<br>3.4 | 7.7<br>6.6 |
| 4. | 12% base nicotine .88 lb.<br>Cube powder .75 lb.<br>Oil 2 quarts | Sta.<br>K.D. | 4.2<br>1.3 | 11.4<br>5.2 |
| 5. | Black leaf-155 1-1/2 lbs.<br>Cube powder 1-1/2 lbs.<br>Oil 1 pint | Sta.<br>K.D. | 2.0<br>8.4 | 10.0<br>21.9 |
| 6. | 12% base nicotine 1.76 lbs.<br>Cube powder 1.5 lbs.<br>Oil 1 pint | Sta.<br>K.D. | 2.5<br>6.1 | 12.2<br>21.0 |
| 7. | Lead arsenate 3 lbs. 2-4th covers<br>Black leaf-155 3 lbs. 5-7th covers | Sta.<br>K.D. | 2.0<br>2.3 | 22.8<br>13.2 |
| 8. | Lead arsenate 3 lbs. 2-4th covers<br>Black leaf-155 2 lbs. and Oil 1 pint 5-7th covers | Sta.<br>K.D. | 5.4<br>2.3 | 29.3<br>14.0 |
| 9. | Lead arsenate 3 lbs. 2-4th, and 2 lbs. 5-7th covers.<br>DN 1-1/2 pints 1-2, 5-7th covers | Sta.<br>K.D. | 0.9<br>0.5 | 10.6<br>3.6 |
| 10. | Lead arsenate 3 lbs. 2-4th covers<br>Genicide 1-1/2 lbs. 5-7th covers | Sta.<br>K.D. | 1.5<br>1.6 | 11.2<br>10.4 |

Table 1. - continued

| Plat No. | Spray program and amount of insecticide per 100 gal: 2nd-9th covers, Plats 1-6; 2nd-7th covers, Plats 7-24 | Variety | Percent Wormy | Percent Total injuries |
|---|---|---|---|---|
| 11. | Lead arsenate 2 lbs. 2-3rd covers and 1 lb. 4-7th covers.<br>Wettable ground timbo root 3.52 lbs.; Oil 1 quart in all covers. | Sta.<br>K.D. | 2.1<br>3.1 | 15.7<br>17.9 |
| 12. | Lead arsenate 3 lbs. | Sta.<br>K.D. | 1.8<br>1.4 | 9.6<br>10.2 |
| 13. | Lead arsenate 3 lbs.<br>Bordeaux 1/2-1-100 as "Corrective" | Sta.<br>K.D. | 0.3<br>2.1 | 9.7<br>21.4 |
| 14. | Lead arsenate 3 lbs.<br>Bordeaux 1/2-2-100 as "Corrective" | Sta.<br>K.D. | 0.2<br>2.1 | 6.7<br>19.1 |
| 15. | Lead arsenate 3 lbs.<br>$ZnSO_4$ 1/2 lb., lime 1 lb. as "corrective" | Sta.<br>K.D. | 0.4<br>1.7 | 6.6<br>21.4 |
| 16. | Lead arsenate 3 lbs.<br>$ZnSO_4$ 1 lb., lime 2 lbs. as "corrective" | Sta.<br>K.D. | 0.3<br>2.5 | 4.3<br>19.9 |
| 17. | Lead arsenate 3 lbs.<br>ZnO 1/2 lb., lime 1 lb. as "corrective" | K.D.(A)<br>K.D.(B) | 2.1<br>1.1 | 20.2<br>8.1 |
| 18. | Lead arsenate 3 lbs.<br>Dinitro-o-cyclohexylphenol 2 oz. | K.D.(A)<br>K.D.(B) | 1.1<br>0.6 | 13.8<br>6.0 |
| 19. | Lead arsenate 3 lbs.<br>Dinitro-o-cresol 2 oz. | K.D.(A)<br>K.D.(B) | 1.9<br>0.2 | 13.9<br>2.8 |
| 20. | Lead arsenate 3 lbs.<br>Dinitro-o-cyclohexylphenol 2 oz.<br>Lime 2 lbs. | K.D.(A)<br>K.D.(B) | 0.5<br>0.9 | 21.8<br>9.2 |
| 21. | Lead arsenate 3 lbs.<br>Dinitro-o-cresol 2 oz.<br>Lime 2 lbs. | Sta.<br>K.D. | 2.8<br>0.8 | 17.1<br>10.2 |
| 22. | Lead arsenate 3 lbs.<br>Sodium dinitro-o-cresylate 4 oz. | Sta.<br>K.D. | 4.1<br>2.5 | 17.7<br>20.9 |
| 23. | Lead arsenate 3 lbs.<br>Dinitro-o-cyclohexylphenol 4 oz.<br>Lime 2 lbs. | K.D. | 1.6 | 13.7 |
| 24. | Lead arsenate 3 lbs.<br>Dinitro-o-cresol 4 oz.<br>Lime 2 lbs. | K.D. | 0.5 | 11.0 |
|  | Checks, no spray | Sta.<br>K.D. | 81.6<br>60.6 | 82.6<br>68.9 |

Sta. = Stayman K.D. = King Davis

In Plat 11, wettable ground timbo root contained 82% timbo root of 4.3% rotenone content.

Table 2.--Results of schedules of Nicotine vs Lead Arsenate
Winchester, Virginia

Note: All plats received: Calyx spray, lead arsenate 3 lbs., lime 1 lb., wettable sulfur 5 lbs; first cover, lead arsenate 4 lbs., lime 4 lbs., flotation sulfur 5 lbs.

| Plat No. | Spray program and amount of insecticide per 100 gallons | Variety | Percent Wormy | Percent Total injuries | Avg. bu. U.S.No.1 fruit per tree |
|---|---|---|---|---|---|
| Plat (B-1) | Black leaf 155 4 lbs., 2-3rd covers; 3 lbs., 4th cover; 2 lbs., 5-7th covers. Oil 1 pint, 2-7th covers | Del.<br>K.D. | 1.4<br>0.6 | 4.9<br>4.1 | 18.1<br>10.5 |
| Plat (B-2) | Black leaf 155 4 lbs., 2-3rd covers; 2-1/2 lbs., 4th cover; 1-1/2 lbs. 5-7th covers. Oil 3 qts. 2-4th covers; 2 qts. 5-7th covers. | Del.<br>K.D. | 1.2<br>0.7 | 3.7<br>3.8 | 11.8<br>9.8 |
| Plat (L)* | Lead arsenate 4 lbs., 2nd cover; 3 lbs., 3-7th covers. Bordeaux 2-4-100, 2nd cover; 1/2-2-100, 3-7th covers. | Del.<br>K.D. | 0.6<br>0.2 | 5.2<br>4.4 | 11.7<br>9.3 |
| Plat (L-)* | Same as (L) but added Spray-lastic 1 pint in 2nd cover and 1 quart in 3-7th covers. | Del.<br>K.D. | 0.7<br>0.2 | 6.5<br>6.5 | 13.9<br>10.4 |
| Checks | | Del.<br>K.D. | 54.3<br>30.6 | 65.3<br>68.9 | |

Del. = Delicious K.D. = King David

* Omitted 7th cover on King David variety.

Dates of sprays: Calyx, May 5-6; covers on May 15, 28-29, June 10-11, 24-25, July 17-18, 27-28, August 6.

## WASHINGTON

W. J. O'Neill and R. L. Webster, State College of Washington
Tree Fruit Branch Experiment Station, Wenatchee

### I. Seasonal Conditions

Losses from codling moth attack were generally higher in 1942 than in 1941. A delayed emergence of moths with cool weather during the period of first brood activity presented excellent prospects for successful codling moth control. Seasonal conditions during the period of second brood activity were favorable to the insect with warm dry weather prevailing well into October. Many orchards suffered losses of 50 per cent or more from codling moth as a result of poorly planned and ineptly applied programs. On the other hand, many orchards produced crops 90 per cent or more entirely free of codling moth injury.

### II. Results of Experimental Work

#### A. Control by Insecticides

(1) Lead arsenate. Experience has shown that in the dry irrigated sections of central Washington arsenical burning of foliage is not generally a problem. Lead arsenate in combination with mineral oils, soaps, or both can be used with little or no attention to arsenical burning. As a result of recent investigations, the present tendency is a return to lead arsenate mineral oil sticker programs with increased oil concentration for ovicides at peaks of egg deposition. Experiments have indicated superior control results from the above program as compared to the "invert" type programs with their emphasis on heavy deposits.

(3) Fluorine compounds. Experiments with fluorine compounds have resulted in fully as good control as that obtained with lead arsenate. Preliminary tests with a natural cryolite said to contain only 70 per cent cryolite resulted in control comparable to the refined natural product with 90 per cent cryolite content. Synthetic cryolite this past season resulted in control equivalent to that resulting from the use of lead arsenate or the natural cryolite.

(5) Organic materials.

(a) Fixed nicotine compounds. Small scale tests consisting of singly replicated single tree plots have resulted in distinctly inferior control with lead arsenate 3 pounds + B. L. Conc. 1-1/2 pounds as compared with a lead arsenate mineral oil program.

(b) Derris compounds. Experimental field tests employing derris as a substitute for mineral oil ovicides have generally resulted in inferior control.

(c) Pyrethrum. An oil pyrethrum spray applied to the trunks and scaffold limbs to kill hibernating larvae gave a high percentage kill of both larvae and trees.

(d) Phenothiazine. Small scale field tests with a micronized phenothiazine have consistently resulted in superior control. As little as 1 to 2 per cent total injury from codling moth as compared to 15 to 40 per cent on adjacent trees. Adverse effects on the fruit and foliage restrict its use to experimental purposes for the present.

(e) Xanthone. Small scale experiments indicate somewhat inferior control during first brood counterbalanced by somewhat superior control in second brood as compared with lead arsenate-mineral oil.

B. Control by Means Other Than Spraying

(1) Scraping and banding. Scraping and banding operations for the entire experimental orchard were omitted in 1942 to offset the cost of other accessory measures of control initiated in 1941. The large (1 acre or larger) demonstration plots consisting of Jonathan, Rome, Delicious, and Winesap varieties were 90 to 95 per cent free of codling moth injury despite the omission of scraping and banding.

(2) Sanitation or accessory measures. Thinning and spacing of fruit is generally practiced on all varieties in the Pacific Northwest. Moreover, this operation is usually performed during the period of first brood attack. Recent investigation has shown that the practice of saving the infested fruits in thinning is at best only 20 to 40 per cent efficient. The majority of the infested fruits are dropped to the ground along with the non-infested fruit. This practice is suggested as the major cause for the heavy second brood attack in many orchards with apparently successful control of first brood.

Treatment of all thinnings by immersion in stove oil has been successful in eliminating this source of potential moth damage. A more detailed report of the advantages of thinning treatment is given by O'Neill in the 1942 Washington State Horticultural Association Proceedings. Separates may be secured by request from this station.

(3) Bait trap studies. Bait traps were run and served as a means of successful timing of sprays, particularly during first brood.

Table 1.--Spray Applications and Materials per 100 gallons.

| Plot | 1st cover 5/18-19 | 2nd cover 5/27-28 | 3rd cover 6/10-11 | 4th cover 6/19-20 | 5th cover 7/2-3 | 6th cover 7/23-24 | 7th cover 8/7-8 |
|---|---|---|---|---|---|---|---|
| Check | L.A. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. | L.A. 3#, Or.K.lt. 2 qts., Coll. 77 1/6 lb. | L.A. 3#, Or.K.lt. 2 qt., Coll.77 1/6 lb. | L.A. 3#, Or.K.lt. 2 qts. Coll.77 1/6 lb. | L.A. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. | L.A. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. | L.A. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. |
| Plot 1 | Kry. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. | Kry. 3#, Or.K.lt. 2 qts., Coll.77 1/6 lb. | Kry. 3#, Or.K.lt. 2 qts., Coll.77 1/6 lb. | Kry. 3#, Or.K.lt. 2 qts., Coll.77 1/6 lb. | Kry. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. | L.A. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. | L.A. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. |
| Plot 2 | Kry. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. | Kry. 3#, Or.K.lt. 2 qts., Coll.77 1/6 lb. | Kry. 3#, Or.K.lt. 2 qts., Coll.77 1/6 lb. | Kry. 3#, Or.K.lt. 2 qts., Coll.77 1/6 lb. | Kry. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. | Kry. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. | Kry. 3#, Or.K.lt. 1 qt., Coll.77 1/6 lb. |
| Plot 3 | Kry. 3#, (special) Or.K.lt. 1 qt.,77 1/6 lb. | Kry. 3#, (special) Or.K.lt. 2 qts., Coll.77 1/6 lb. | Kry. 3#, (special) Or.K.lt. 2 qts., Coll.77 1/6 lb. | Kry. 3#, (special) Or.K.lt. 2 qts., Coll.77 1/6 lb. | Kry. 3#, (special) Or.K.lt. 1 qt.,77 1/6 lb. | Kry. 3#, (special) Or.K.lt. 1 qt.,77 1/6 lb. | Kry. 3#, (special) Or.K.lt. 1 qt.,77 1/6 lb. |
| Plot 4 | Alorco 3#,Or.K. lt. 1 qt. | Alorco 3#, Or. K.lt. 2 qts. | Alorco 3#, Or. K.lt. 2 qts. | Alorco 3#,Or.K. lt. 2 qts. | Alorco 3#,Or.K. lt. 1 qt. | Alorco 3#,Or.K. lt. 1 qt. | Alorco 3#,Or.K. lt. 1 qt. |
| Plot 5 | Kry. 3#, Or.K.lt. 1 qt. | Kry. 3#, Or.K.lt. 2 qts. | Kry. 3#, Or.K.lt. 2 qts. | Kry. 3#, Or.K.lt. 2 qts. | Kry. 3#, Or.K.lt. 1 qt. | Kry. 3#, Or.K.lt. 1 qt. | Kry. 3#, Or.K.lt. 1 qt. |
| Plot 6 | L.A. 3#, Or.K.lt. med. 1 qt. Coll. 77 1/6 lb. | L.A. 3#, Or.K.lt. med.2 qt. Coll. 77 1/6 lb. | L.A. 3#, Or.K.lt. med.2 qts. Coll. 77 1/6 lb. | L.A. 3#, Or.K.lt. med. 2 qt. Coll. 77 1/6 lb. | L.A. 3#, Or.K.lt. med. 1 qt. Coll. 77 1/6 lb. | L.A. 3#, Or.K.lt. med. 1 qt. Coll. 77 1/6 lb. | L.A. 3#, Or.K.lt. med. 1 qt. Coll. 77 1/6 lb. |
| Plot 7 | L.A. 3#, Or.K.med. 1 qt., Coll. 77 1/6 lb. | L.A. 3#, Or.K.med. 2 qts., Coll. 77 1/6 lb. | L.A. 3#, Or.K.med. 2 qts., Coll. 77 1/6 lb. | L.A. 3#, Or.K.med. 2 qts., Coll. 77 1/6 lb. | L.A. 3#, Or.K.med. 1 qt., Coll. 77 1/6 lb. | L.A. 3#, Or.K.med. 1 qt., Coll.77 1/6 lb. | L.A. 3#, Or.K.med. 1 qt., Coll. 77 1/6 lb. |
| Plot 8 | L.A. 3#, Or.K.lt. 1 qt. | L.A. 3#, Or.K.lt. 2 qts. | L.A. 3#, Or.K.lt. 2 qts. | L.A. 3# Or.K.lt. 2 qts. | L.A. 3#, Or.K.lt. 1 qt. | L.A. 3#, Or.K.lt. 1 qt. | L.A. 3#, Or.K.lt. 1 qt. |
| Plot 9 | L.A. 3#, Or.K.med. 1 qt. | L.A. 3#, Or.K.med. 2 qts. | L.A. 3#, Or.K.med. 2 qts. | L.A. 3#, Or.K.med. 2 qts. | L.A. 3#, Or.K.med. 1 qt. | L.A. 3#, Or.K.med. 1 qt. | L.A. 3#, Or.K.med. 1 qt. |
| Plot 10 | L.A. 3#, Or.K.lt. 1 qt. | L.A. 2#, Or.K.lt. 2 qts. | L.A. 2#, Or.K.lt. 2 qts. | L.A. 2#, Or.K.lt. 2 qts. | L.A. 3#, Or.K.lt. 1 qt. | L.A. 3#, tar soap 1/5 lb. | L.A. 3#, tar soap 1/5 lb. |

Abbreviations used in above table: L.A. - lead arsenate; Kry. - Kryocide; Or.K.lt. - Orthol K light; Or.K.lt.med. - Orthol K light medium; Ortho K. med. - Ortho K medium; Coll. 77 - Colloidal 77; # - pound.

TABLE II. Summary of per cent codling moth injury for harvested fruit only. Each plot indicates the average of two or three trees.

| Series and Plot No. | Est. No. fruits | Per cent clean | Per cent stung | Per cent wormy | Worms per 100 |
|---|---|---|---|---|---|
| Red Series | | | | | |
| Red 1 | 2484 | 89 | 4 | 7 | 8 |
| Red check | 3309 | 91 | 4 | 5 | 6 |
| Red 2 | 2836 | 92 | 4 | 4 | 5 |
| Red 3 | 2412 | 90 | 5 | 5 | 6 |
| Red check | 3547 | 90 | 4 | 6 | 8 |
| Red 4 | 3075 | 90 | 4 | 6 | 6 |
| Red 5 | 4319 | 92 | 4 | 4 | 5 |
| Red check | 3841 | 88 | 5 | 7 | 10 |
| Red 6 | 3793 | 90 | 4 | 6 | 7 |
| Red 7 | 3924 | 90 | 4 | 6 | 8 |
| Red check | 3696 | 87 | 6 | 7 | 8 |
| Red 8 | 3104 | 88 | 4 | 8 | 11 |
| Red 9 | 3401 | 91 | 5 | 4 | 5 |
| Red check | 3094 | 94 | 3 | 3 | 5 |
| Red 10 | 3616 | 84 | 5 | 11 | 15 |
| Black Series | | | | | |
| Black 1 | 3581 | 89 | 5 | 6 | 8 |
| Black check | 4375 | 92 | 5 | 3 | 4 |
| Black 2 | 3825 | 94 | 3 | 3 | 4 |
| Black 3 | 3939 | 88 | 8 | 4 | 5 |
| Black check | 2802 | 86 | 7 | 7 | 9 |
| Black 4 | 3829 | 86 | 6 | 8 | 10 |
| Black 5 | 3992 | 91 | 4 | 5 | 5 |
| Black check | 4354 | 94 | 4 | 2 | 3 |
| Black 6 | 3601 | 94 | 3 | 3 | 3 |
| Black 7 | 4402 | 91 | 4 | 5 | 6 |
| Black check | 3028 | 96 | 2 | 2 | 2 |
| Black 8 | 2273 | 88 | 6 | 6 | 8 |
| Black 9 | 4304 | 93 | 3 | 4 | 5 |
| Black check | 3475 | 89 | 5 | 6 | 7 |
| Black 10 | 2969 | 83 | 5 | 12 | 18 |
| Orange Series | | | | | |
| Orange 1 | 3453 | 71 | 9 | 20 | 29 |
| Orange 2 | 2853 | 74 | 9 | 17 | 23 |
| Orange check | 3719 | 81 | 6 | 13 | 19 |
| Orange 3 | 4061 | 87 | 4 | 9 | 13 |
| Orange 4 | 3523 | 83 | 4 | 13 | 17 |
| Orange check | 4513 | 89 | 4 | 7 | 7 |
| Orange 5 | 5078 | 88 | 5 | 7 | 9 |
| Orange 6 | 4743 | 89 | 5 | 6 | 8 |
| Orange check | 4876 | 92 | 4 | 4 | 6 |
| Orange 7 | 5284 | 87 | 5 | 8 | 11 |

TABLE II. (Continued)

| Series and Plot No. | Est. No. fruits | Per cent clean | Per cent stung | Per cent wormy | Worms per 100 |
|---|---|---|---|---|---|
| | | Orange Series | | | |
| Orange 8 | 4521 | 86 | 5 | 9 | 12 |
| Orange check | 4713 | 83 | 5 | 10 | 16 |
| Orange 9 | 4419 | 82 | 6 | 12 | 16 |
| Orange 10 | 3753 | 68 | 7 | 25 | 43 |
| Orange check | 3660 | 77 | 7 | 16 | 24 |

## COVERAGE ANALYSES

By Herman Fallscheer

Both lead and fluorine coverage analyses were made using 40 to 80 discs cut from 12 to 20 apples. Duplicate samples were taken for analysis and the fruit was picked from all sections of the tree. Arsenical analyses were made according to the bromate titration method as listed in "Methods of Analysis", A. O. A. C., 1940. Fluorine was determined according to a modified A. O. A. C. method in which the sample is ashed with MgO, distilled with perchloric acid and the distillate titrated with thorium nitrate.

Arsenical Coverage

| Plot | Spray* | Micrograms $As_2O_3$ per $cm^2$<br>After 3rd cover | Before 4th cover | After 4th cover | After 6th Cover | 26 days after the applications of 7th cover spray (9/2) |
|---|---|---|---|---|---|---|
| 8 | L.A. 3 lbs., Ortho K lt. oil | 20.2 | 14.5 | 24.7 | 26.9 | 26.5 |
| 10 | L.A. 2 lbs., with ovicides, 1st brood. L.A. 3 lbs.. tar soap, second brood. | 16.9 | 12.3 | 21.3 | | 22.2 |
| Ch | L.A. 3 lbs.. Ortho K lt. oil, Coll. 77 | 27.5 | 16.7 | 37.7 | 31.2 | 34.0 |
| 6 | L.A. 3 lbs. Ortho lt. med. oil + Coll. 77 | 27.1 | | 41.6 | 34.2 | |
| 7 | L.A. 3 lbs., Ortho K medium oil | 24.3 | | | 31.2 | 31.1 |
| 9 | L.A. 3 lbs., Ortho K medium oil,. Coll. 77 | | | | 30.2 | 28.6 |
| | Fluorine Coverage | | | | | Mmg. F per $cm^2$ |
| 2 | Cry. 3 lbs.. Ortho K lt. oil Coll 77 | | | 49.8 | | 37.7 |
| 3 | Cry. (spec.) 3 lbs.. Ortho K lt. oil, Coll. 77 | | | 32.2 | | 38.2 |

[illegible] (Continued)

Fluorine Coverage

| Plot | Spray* | After 3rd cover | Before 4th cover | After 4th cover | After 6th cover | 26 days after the applications of 7th cover spray (9/2) |
|---|---|---|---|---|---|---|
| 4 | Cry. (synthetic) 3 lbs., Ortho K lt. oil | | | 33.7 | | 28.2 |
| 5 | Cry. 3 lbs., Ortho K lt. oil | | | 43.3 | | 43.5 |

* Complete spray program is given in preceding section under codling moth investigations.

## SPRAY RESIDUE

By F. L. Overley and Herman Fallscheer

The Experiment Station acquired a new Cutler single acid washing machine in the fall of 1942. The machine had a stepover type conveyor with over head flood. The fruit was in the acid section for 33 seconds and in the rinse water for 33 seconds. Hydrochloric acid at 1.5 per cent was used and the temperature varied from 60° F. to 38° F. The samples consisted of one-half to one box of fruit selected from the picked fruit of each plot. All lead determinations were made in duplicate according to the method outlined in "Methods of Analysis", A. O. A. C., 1940. The fluorine residues were determined using the Food and Drug method of 1935, the final color comparisons being made photometrically. Fruit from the experimental plots was harvested on October 3 and 5. All fruit was washed on October 10. Lead and fluorine residue results on these fruits are tabulated in the following tables.

Lead residue removal on fruit from the experimental spray plots of 1942. Jonathan apples.

| Plot No. | Spray program: lead arsenate 3 pounds, plus | Number of covers | Lead residue in grains per pound of fruit: Before washing | After washing HCL 1.5% at 60° F. |
|---|---|---|---|---|
| 6 | Lt. mod. Ortho K oil 1 and 2 qts. Coll. 77 | 7 | .28 | .031 |
| 7 | Med. Ortho K oil 1 and 2 qts., Coll. 77 | 7 | .30 | .033 |
| 8 | Lt. Ortho K oil 1 and 2 qts. | 7 | .25 | .028 |
| 9 | Med. Ortho K oil 1 and 2 qts. | 7 | .36 | .037 |
| Ch | Lt. Ortho K oil 1 and 2 qts., Coll. 77 | 7 | .30 | .022 |
| 10 | L.A. 2 and 3 lbs., lt. Ortho K oil 1 and 2 qts. (first brood); L.A. 3 lbs., tar soap 1/5 lb. (second brood) | 7 | .21 | .023 |
| Ch | Same as above | 7 | .21 | .014** |

**Run through the washer twice.

Fluorine residue removal on fruit from the experimental plots of 1942.

| Plot No. | Spray Program | Number of covers of cryolite | Fluorine residue in grains per pound of fruit |  |
|---|---|---|---|---|
|  |  |  | Before washing | After washing HCL 1.5% at 60°F. |
| 1 | Cry. 3 lbs., lt Ortho K oil 1 and 2 qts., Coll. 77 (first brood); L.A., lt. Ortho K oil 1 qt., Coll.77 (second brood) | 5 | .058* | .023 |
| 2 | Cry. 3 lbs., lt. Ortho K oil 1 and 2 qts., Coll. 77 | 7 | .110* | .031 |
| 3 | Cry. (special) 3 lbs., lt. Ortho K oil 1 and 2 qts., Coll. 77 | 7 | .09* | .033 |
| 4 | Cry. (synthetic) 3 lbs., lt. Ortho K oil 1 and 2 qts. | 7 | .100* | .021 |
| 5 | Cry. 3 lbs., lt. Ortho K oil 1 and 2 qts. | 7 | .100* | .033 |

*Single analysis

All of the Jonathan samples from the experimental plots were effectively cleaned to a point below the Federal tolerance for lead by the single acid cold wash. All of the spray programs might be considered moderate, although two plots (7 and 9) did have medium summer oil. For further information on spray programs, see section on codling moth investigations.

While the single cold acid wash was effective in cleaning the lead residues, none of the fluorine residues were reduced to the tolerance of .02 grains per pound of fruit. Fruit sprayed with special cryolite (low grade) was cleaned to the same degree as that sprayed with the regular grade cryolite. The fruit sprayed with the synthetic cryolite was cleaned to a lower figure than that sprayed with the natural product in an identical spray program.

## CANADA

Jas. Marshall, Dominion Entomological Laboratory, Vernon,
British Columbia.

### 1. Larvicide Investigations (Mature Larvae)

### A. Field Experiments

Approximately four acres of mature apple trees were used in "trunk spray" experiments in 1941. (Sc. Agr. 22:10, 571-576, 1942) Application of Diesel oil (40 S.S.U. Vis., 70% U.R.) containing 2% 3,5-dinitro-o-cresol at 100% concentration in the delayed dormant period, resulted in considerable cambium injury but killed practically all larvae on the tree trunks. Check trees that received only the regular summer codling moth sprays were 36% infested at harvest while the trees that received the trunk treatment in addition were 7% infested.

In 1942 seven acres of mature trees were treated with trunk sprays with the object of determining the most valuable type of oil for the work as well as the minimum concentrations of oil and dinitrocresol required. Diesel oil-dinitrocresol solution as described above, but used at 10% concentration instead of 100%, killed approximately 50% of the larvae on the tree trunks. No injury has been detected from this treatment. It appears that the optimum oil concentration has now been "bracketed" and that it should be possible to obtain, let us say, 90% mortality of larvae without serious danger to the trees.

Application of summer trunk treatments consisting of water suspensions of dinitrocresol as well as oil emulsions in conjunction with dinitrocresol, suggest that it may prove desirable to attack the first generation larvae while they are cocooning in July.

### B. Laboratory Experiments

It did not seem necessary to use large amounts (5 lb:100 gal.) of sodium lauryl sulphate with Diesel oil-dinitrocresol solution in order to promote penetration of cocoons as well as to emulsify the oil. Approximately 2.5 lb. sodium lauryl sulphate seemed satisfactory as did 0.5 lb. lignin pitch.

Addition of oxalic acid to the Diesel oil-dinitrocresol-water-emulsifier system in order to prevent diffusion of toxicant from oil to water did not give conclusive evidence but may prove to be desirable. Water suspensions of dinitrocresol as "Dinitro Dry" with various wetting agents did not appear as promising against cocooned larvae as emulsions of Diesel oil containing much smaller amounts of dinitrocresol in oil solution.

## 2. Larvicide Investigations (First Instar Larvae)

### A. Field Experiments

Phenothiazine (micronized) has for the second successive year given codling moth control superior to lead arsenate in the semi-arid Okanagan Valley. It has been more than twice as effective as lead arsenate pound for pound when wetted by a soap emulsion of stove oil as suggested by E. J. Newcomer of the U.S.D.A., Yakima, Washington laboratory. Finish of fruit has not been adversely affected by four cover sprays. Phenothiazine has caused difficulty by irritating the skin of spraymen and thinners in hot weather, but the chief bar to its present use in this area is cost.

Cryolite. Satisfactory evidence has been provided on the following points in relation to control in the Okanagan Valley:

a) Cryolite has been for practical purposes as effective as lead arsenate.
b) The most effective non-oil adjuvant for cryolite has been protein-lime spreader despite the fairly general opinion that lime and cryolite should not be used together. (Proc. Ent. Soc. B.C. 39:19-20. 1942)
c) Synthetic cryolite ("Alorco") and natural cryolite ("Kryocide") have proved equally effective in a series of investigations covering the years 1940, 1941, 1942. (Proc. Ent. Soc. B.C. 40. 1943.)

Petroleum Oil of low sulphonation value (75% U.R.) has proved to be quite satisfactory at 0.5% concentration in summer codling moth sprays providing no more than two applications have been made. Most of the oil used in the Okanagan Valley in 1943 will be of this type.

"Fixed Nicotine" made by dry-mixing nicotine sulphate and air-floated Drumheller, Alberta bentonite has been demonstrated an effective spray mixture for second brood codling moth control when used with petroleum oil. Unlike the tank-mixed material this preparation is readily removed from the fruit by a wiper.

### B. Laboratory Experiments

Cadmium nitrate has been found very toxic to first instar larvae when applied at 3.75 pounds per 100 gallons. At this concentration however, it caused injury to fruit.

Ammonium dinitrocresylate and sodium dinitrocresylate did not lower the larvicidal value of lead arsenate or cryolite when added in the small amount necessary to kill codling moth adults by ingestion.

Lime sulphur lowered the larvicidal value of cryolite but elemental sulphur seemingly had little effect. (Proc. Ent. Soc. B.C. 39:19-20, 1942.)

## 3. Moth Insecticide Investigations

### A. Field Experiments

A field experiment in 1941 indicated that a dinitrophenol derivative such as ammonium dinitrocresylate may be applied as a summer spray to certain varieties of apple, such as Wealthy and McIntosh, at such a concentration (4 oz. dinitrocresol equivalent per 100 imp. gallons), that codling moth adults may be killed by ingesting the residue without the incidence of foliage injury (Sc. Agr. 22:10, 577-583. 1942). By this procedure a measurable reduction in codling moth infestation at harvest was attained.

Experiments of the past season have shown that the "Moth spray" alone, which is quite innocuous to larvae, does not appear sufficient to prevent considerable infestation. A concentration of dinitrocresol that caused no injury to healthy foliage in 1941 caused obvious injury at the site of scab lesions, in 1942.

### B. Laboratory Experiments

The potassium, monoethanolamine, nicotine and ammonium salts of dinitro-cresol appeared somewhat more toxic to moths than the sodium salt.

Water alone appeared to be as satisfactory for survival of moths and for oviposition as water solutions of sucrose, maltose, laevulose and dextrose. Death occurred more quickly in absence of water.

## 4. Combined Treatments for Mature Larvae, First Instar Larvae and Moth

This year two blocks of mature apple trees, each of about three acres, were given a delayed dormant trunk spray of 10% Diesel oil emulsion, the Diesel oil containing 2% dinitrocresol. This was followed by the applications of lead arsenate and cryolite as currently recommended (4 in one orchard, 6 in the other) to which were added ammonium dinitrocresylate or sodium dinitrocresylate at the rate of 4 oz. dinitrocresol equivalent per 100 gallons spray mixture.

In the first orchard, infestation at harvest was as follows:

| | McIntosh | Wealthy |
|---|---|---|
| Experimental Block | 21% | 12% |
| Check (standard sprays only) | 31% | 36% |

There is reason to feel that topography and previous year's infestation favoured the check block in the case of McIntosh. Cost of trunk treatment and summer additions of dinitrocresylate totaled approximately 1 cent per box, labour included.

As mentioned earlier the trunk treatment killed only 50% (approx.) of the overwintered larvae so the effect of the moth spray appears to have been considerable.

In the second orchard infestation at harvest was:

| | McIntosh |
|---|---|
| Experimental Block | 12% |
| Check (Standard sprays only) | 32% |

Records were kept of size of fruit in this case and corroboration of 1941 results was obtained. Trees that received six applications of sodium or ammonium dinitrocresylate bore fruit approximately 20% greater in size than did the check trees. The increase in size of fruit was borne out in numbers of boxes harvested. There appears no doubt of stimulative effect but its nature is not yet clear. Fruit from the experimental block so far is keeping well in storage. No injury to tree trunks or foliage of Wealthy or McIntosh has been noted in these experiments but slight "tip-burn" was caused to foliage of Duchess by an early ammonium dinitrocresylate application. It is hoped other investigators will undertake similar work very shortly for trunk and moth sprays appear promising as a means of avoiding oil sprays and lowering the cost of control. But much remains to be done.

## 5. Parasite Introductions

The parasite Ephialtes caudata was introduced into the Okanagan Valley in the fall of 1941. It is not known if it has established itself. The parasite Cryptus sexannulatus was introduced in 1942. Both shipments were from the Dominion Parasite Laboratory, Belleville, Ont. Ascogaster carpocapsae introduced a number of years ago now appears to be fairly generally distributed in the Okanagan Valley. It has not so far proved to be a factor of economic importance.

## 6. Deblossoming for Codling Moth Control

An orchard 300 yards removed from the nearest neighboring property was sprayed at the pink stage in 1941 for the purpose of preventing fruit set. The spray, 2% high boiling neutral tar oil, removed approximately 90% of the crop. The remaining fruits were removed by hand and destroyed before codling moth larvae could mature in them. As far as could be determined no larvae matured in the orchard in 1941. In the spring of 1942, after less than an hour's search, three men found seven larvae and one pupa in particularly sheltered places on the lower tree trunks. There is good reason to feel that these were "2 year larvae". The 1942 crop was infested from 75% to 90% according to variety. No sprays had been applied.

Further experiments have indicated that dinitrophenol derivatives such as dinitrocresol and dinitrocyclohexylphenol either in water suspension or used with oil emulsions, are more effective and less expensive for deblossoming than is tar oil. They appeared however to be more destructive to fruit spurs.

## 7. Behaviour of Codling Moth Larvae.

When a very small puncture (0.25 mm. in diameter, 1 mm. in depth) was made in the cuticle of an immature apple and a newly emerged codling moth larva placed upon the opposite side of the apple, it was found that the larva was able to locate and enter the puncture more frequently than would be indicated by chance. On uninjured fruits 55% of the larvae entered through the calyx and 15% through the side. On fruits punctured on the side however, 52% of the larvae entered through the puncture. It has been found that mortality on sprayed fruits is less when preformed sites of entry such as artificially made punctures or attempted larval entries are present. When both points are considered, it appears that here may be an explanation for the state of affairs in which control has appeared to become more than proportionately harder to attain as codling moth populations have increased.

## CANADA

Harold T. Stultz, Dominion Entomological Laboratory, Annapolis Royal, Nova Scotia

## I. Seasonal conditions and abundance of the insect during the 1942 season

In the Annapolis Valley monthly temperatures throughout the growing season were all above the average for the area. At Kentville the variations from the average means for the months April to September inclusive were: +1.0, +4.2, +1.6, +2.9, +2.7 and +3.1 degrees; an accumulated excess of 15.5 degrees. Except for the month of September, precipitation for the period April to September was somewhat below the average. At Kentville the recorded precipitations for these months were: 2.27, 2.07, 1.58, 2.00, 2.11 and 10.58 inches. The various stages for apple development all occurred rather earlier than usual. Full bloom of McIntosh occurred about May 23rd. Complete closure of calyces for this variety occurred about June 15th. The fruit was ready to harvest about September September 20th.

The various stages of codling moth development also occurred somewhat earlier than usual. At Berwick the first moths were seen on May 26th (June 8th in 1941); about 50 per cent had emerged by June 25th (July 2nd in 1941). The first larval entries into the fruit were made about June 21st (July 1, 1941). Mature larvae started leaving the fruit about July 19th (July 28th in 1941). Of the larvae maturing up to July 25th a small number (approximately 1 per cent) pupated and eventually emerged as moths during the current season. This is the first season since codling moth studies were started three years ago that any second generation eggs and larvae have been obtained from reared insects. This is also the first year that second generation entries have occurred to an appreciable amount in the orchard. In the heavily infested area around Berwick quite serious damage resulted from these late-entries in the variety Golden Russet and, to a lesser extent, in Wagener and Northern Spy. Earlier varieties, however, did not suffer much damage from late entries. This severe damage from late entries which occurred in some varieties at Berwick was restricted to an area in which some heavily infested orchards had been left unsprayed during the season of 1942. As a result a very large population of first generation larvae developed in this area. Therefore, even though the percentage which pupated and emerged as moths was very small, yet, the actual number of moths was enough to result in a large number of entries late in the season.

## II. Studies in codling moth biology and behavior.

Eggs - The minimum incubation period in the insectary was 7 days, one day shorter than that observed in 1940 or 1941. However, this minimum period occurred in the case of only a few daily hatches of eggs.

Larvae - Four short sections of apple tree limbs, each with a burlap band around it, were set upright on the ground at various distances from the trunk of an unsprayed Gravenstein tree which carried a full crop of apples heavily infested with codling moth larvae. During the season the following numbers of larvae were taken under the bands on each of these sticks placed at the distances indicated from the tree trunk.

| | Distance from main trunk | Normal larvae | Parasitized by A. carpocapsae |
|---|---|---|---|
| Stick #1 | 3 feet | 59 | 17 |
| Stick #2 | 10 feet | 6 | 0 |
| Stick #3 | 20 feet | 1 | 0 |
| Stick #4 | 30 feet | 0 | 0 |

The total for the band on the trunk of this tree was 515 larvae of which 43.3 per cent were parasitized by Ascogaster carpocapsae.

Parasitism by A. carpocapsae showed a sharp increase in a large orchard at Berwick which was left unsprayed in 1942, averaging 46.0 per cent as compared with approximately 17 per cent in 1941 when the orchard was sprayed. In an adjacent orchard which has been sprayed with lead arsenate, cryolite and summer oil for two years for the control of codling moth, only 8 per cent of the larvae were parasitized as compared with 11 per cent in 1941.

In an orchard in the same general area which has had no care whatever for many years the percentage parasitism by A. carpocapsae remains about the same as in 1940 and 1941, being 63 per cent in 1942.

One of the interesting developments observed during the past season was the relative numbers of the different types of codling moth entries which occurred in three adjacent commercial orchards at Berwick, one of which was sprayed for codling moth control by our staff, using a lead arsenate, cryolite and summer oil program; the second was rather indifferently sprayed by the owner who used lead arsenate with a sulphur fungicide, including summer oil in one spray; and the third, a large block, was left unsprayed except for 48 trees which were used for a codling moth control experiment by our staff. The following table compares the amounts of injuries found on the fruit in the three different orchards:

| | Poorly sprayed orchard | | Well sprayed orchard | | Unsprayed orchard | |
|---|---|---|---|---|---|---|
| Variety | McI. | G. Russet | McI. | G. Russet | Grav. | G. Russet |
| Stings per 100 apples | 127 | 114 | 21 | 24.7 | 9 | 5 |
| Deep side entries per 100 apples | 71 | 50 | 8 | 5 | 74 | 71 |
| Deep calyx entries per 100 apples | 0 | 0 | 0 | 0 | 59 | 44 |
| Total deep entries per 100 apples | 71 | 50 | 8 | 7.7 | 133 | 115 |
| Total entries per 100 apples | 198 | 164 | 29 | 32.4 | 142 | 120 |
| Injured fruit per 100 apples | 88 | 83 | 29 | 23 | 72 | 84 |
| The above entries included the following numbers of second generation entries per 100 apples. | 4 | 15 | 7 | 4 | 8 | 17 |

Legend:

McI. - McIntosh; G. Russet - Golden Russet;
Grav. - Gravenstein.

In both the unsprayed and poorly sprayed orchards, many codling moth eggs were destroyed by an egg parasite, apparently Trichogramma sp. On July 16th an egg count made in the unsprayed orchard indicated that only about 4 per cent were not parasitized, and most of these were freshly laid. In the poorly sprayed orchard, at this time, 20 per cent of the eggs were not parasitized, many of them being in the red ring stage. Although the percentage of parasitized eggs kept increasing in the latter orchard there were still some unparasitized eggs by the end of August. These egg counts were made because of the fact that fresh first generation larval entries had almost ceased in the unsprayed orchard by the middle of July. In fact, they dropped off quite sharply after July 2nd. On the basis of the 1942 bait pan and moth emergence records, as well as new entry records for the past two years, the peak of new entries should have occurred about the middle of July. In fact this is the time (July 16th) that it did occur in the poorly sprayed orchard in 1942. Fresh entries occurred in large numbers (30 or more per 500 apples) for a month longer in the poorly sprayed than in the unsprayed orchard.

## III. Results of control experiments

The block of 48 trees in the unsprayed orchard mentioned above was divided into 12 plots consisting of two Gravensteins and one each of Golden Russet and Baldwin per plot. The object was to gain information concerning the effectiveness of lead arsenate when used at different times throughout the spraying season. Even though the number of trees used is very small, the results are at least suggestive.

The sprays, dates of application and the main results of the examination of drops and picked fruit are shown in the following table:

| Plot | Spray applications and materials 1/ | Gravenstein Entries per 100 apples | | | Russet Entries per 100 apples | | | Baldwin Entries per 100 apples | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Calyx | Deep | Total | Calyx | Deep | Total | Calyx | Deep | Total |
| 1 | (P,C,1,2)F | 46 | 96 | 102 | 20 | 146 | 179 | 11 | 120 | 141 |
| 2 | none | 59 | 122 | 132 | 37 | 116 | 121 | 20 | 105 | 120 |
| 3 | (P)F-LA,(C,1,2)F | 9 | 76 | 87 | 5.7 | 117 | 156 | 2.3 | 106 | 143 |
| 4 | P(F-LA) | 13 | 59 | 72 | 3 | 96 | 130 | 2.6 | 71 | 116 |
| 5 | (P,1,2)F,(C)F-LA | 5 | 64 | 85 | 2 | 84 | 130 | 0.9 | 77 | 127 |
| 6 | (P,C)F-LA,(1,2)F | 1.2 | 81 | 119 | 0.3 | 117 | 164 | 0.4 | 74 | 172 |
| 7 | (P,C,1,2)F-LA | 0.2 | 28 | 48 | 0.2 | 61 | 153 | 0.3 | 33 | 120 |
| 8 | (P)F,(C,1,2)F-LA | 0.5 | 23 | 52 | 0 | 74 | 145 | 0.2 | 29 | 106 |
| 9 | (P)F,(C,1,2)F-LA, (3)LA | 0.8 | 12 | 45 | 0 | 41 | 161 | 0 | 11 | 82 |
| 10 | (P)F,(C,1,2)F-LA, (3,4)LA | 0.9 | 15 | 56 | 0 | 15 | 121 | 0 | 6 | 90 |
| 11 | (P)F,(C,1,2)F-LA, (3,4,5)LA | 0.5 | 4 | 31 | 0 | 9 | 94 | 0.1 | 5.2 | 96 |
| 12 | (P)F,(1,2)F-LA, (3,4,5)LA | 2.3 | 8 | 51 | 0.4 | 12 | 90 | 2 | 2 | 51 |

1/ Symbols in parentheses designate applications, others materials. P-pink spray, May 19; C-calyx spray, June 2; 1-first cover, June 12; 2-second cover, June 23; 3-third cover, July 3; 4-fourth cover, July 14; 5-fifth cover, July 23; F-flotation sulphur (15 pounds per 100 Imperial gallons); LA-lead arsenate (4 pounds per 100 Imperial gallons).

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# RESULTS OF CODLING MOTH INVESTIGATIONS, 1942

## Part II

Work Conducted by the Bureau of Entomology
and Plant Quarantine, Agricultural Research
Administration, U. S. Department of
Agriculture

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# RESULTS OF CODLING MOTH INVESTIGATIONS, 1942

## Part II

Work Conducted by the Bureau of Entomology
and Plant Quarantine, Agricultural Research
Administration, U. S. Department of
Agriculture

This summary represents the contribution of the Division of Fruit Insect Investigations of the Bureau of Entomology and Plant Quarantine to the pool of information on the results of codling moth investigations carried on during 1942 which has been prepared in accordance with a request made by the Committee on the Codling Moth of the American Association of Economic Entomologists. As in previous years, this is a preliminary report, circulated for the information of those interested. It is subject to revision as further review of the data may indicate, and has the status of unpublished data, not subject to quotation without permission.

The work of the Division of Fruit Insect Investigations is carried on cooperatively with several Bureau and Department units, as well as with a number of State agencies. The Division of Insecticide Investigations has continued to contribute to the work reported herein, and joint field laboratories are maintained at Yakima, Washington and at Vincennes, Indiana. The work in West Virginia is carried on jointly by the West Virginia Agricultural Experiment Station and the Bureau; the work in New York State is carried on similarly with the New York Agricultural Experiment Stations.

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## KEARNEYSVILLE, WEST VIRGINIA

Edwin Gould, West Virginia Agricultural Experiment Station
and G. H. Geissler, Bureau of Entomology and Plant Quarantine,
U. S. Department of Agriculture.

These investigations were carried on jointly by the Bureau of Entomology and Plant Quarantine and the West Virginia Agricultural Experiment Station.

### 1. Seasonal Conditions and Codling Moth Abundance during the 1942 Season.

The development of fruit and insects in the Shenandoah-Cumberland fruit belt during 1942 was early, and in some ways similar to the 1941 season. The general peak of bloom took place in late April with good conditions for pollination. A fairly heavy crop of apples resulted.

Moth activity, as determined by bait pails, began on May 1 and by May 6 had reached peak proportions. This condition was almost identical with the 1941 record and is about normal for the area. The first entry was observed on May 22 and by June 10 the heaviest portion of first brood hatch was taking place. Extremely wet weather during May and June greatly reduced the number of entries and resulted in only a moderate first brood infestation. During second brood, however, better climatic conditions prevailed and a considerable increase of infested fruit became apparent. Warm weather prevailed throughout the latter part of the season and an unusually heavy late hatch occurred in September. The resulting late larval entries will doubtless contribute to a fairly heavy winter carry-over of larvae. Studies of hatching and entry for the past four years indicate that at least 20 days usually elapse between the initial activity of moths as recorded by the bait pails and the first larval entry.

### 2. Field Experiments with Insecticides.

Spray testing experiments for 1942 were divided into two major groups; the regular experimental plots, and a group of treatments pertaining to the most effective use of a reduced amount of lead arsenate.

#### Regular Experimental Plots.

These treatments were primarily concerned with the efficiency of unconditioned versus conditioned micronized phenothiazine. The phenothiazines were used at various concentrations and were also used as "boosters" in certain schedules. Ten treatments were applied in each of two orchards. All plots received 4 first brood cover sprays and a fifth cover was applied against second brood for all treatments except No. 6.

The schedules and results are presented in tables 1 and 2.

Table 1.--Results of field experiments with insecticides for codling moth control - Gatrell Orchard - Kearneysville, W. Va. - 1942.

| Treatment No. | Covers | Materials 1/ (Amounts per 100 gal.) | Total Fruits | Percent inj. fruits | | Percent wormy frts. | | Total harvest injuries per 100 fruits | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 1st. brood | Harvest | 1st brood | Harvest | Worms | Stings |
| 1. | 1<br>2-5 | LA 3#; LS 2 gal.; L 3#<br>LA 3#; Bord. 1/2-1-100 | 13,142 | 29.7 | 43.8 | 0.8 | 3.5 | 4 | 64 |
| 2. | 1<br>2-4<br>5 | LA 3#; LS 2 gal.; L 3#<br>Mic. Pheno.(Uncond.)2#<br>LA 3#; Bord. 2-4-100 | 12,972 | 14.1 | 26.3 | 5.9 | 13.2 | 18 | 21 |
| 3. | 1-5 | Mic. Pheno.(Uncond.)2# | 11,442 | 9.7 | 22.0 | 5.4 | 17.9 | 24 | 6 |
| 4. | 1<br>2-4<br>5 | LA 3#; LS 2 gal.; L 3#<br>Mic. Pheno.(Cond.) 2#<br>LA 3#; Bord. 2-4-100 | 12,763 | 11.1 | 23.3 | 2.4 | 9.3 | 12 | 20 |
| 5. | 1-5 | Mic. Pheno. (Cond.) 2# | 15,629 | 9.2 | 15.6 | 4.5 | 12.1 | 16 | 5 |
| 6. | 1-4 | Mic. Pheno.(Uncond.)2# | 16,350 | 5.0 | 19.2 | 2.6 | 17.2 | 24 | 3 |
| 7. | 1-5 | Mic. Pheno.(Uncond.)3# | 18,418 | 3.5 | 6.2 | 2.3 | 4.8 | 6 | 1 |
| 9. | 1<br>2<br>3-5 | LA 3#; LS 2 gal.; L 3#<br>LA 3#; Bord. 1/2-1-100<br>LA 3#; GAP 24#; Bord. 1/2-1-100 | 13,184 | 31.2 | 44.0 | 1.0 | 6.6 | 8 | 64 |
| 11. | 1-5 | Mic. Pheno.(Uncond.)2#; Stove Oil 1 qt; Soap 1-1/2# | 16,013 | 21.8 | 31.8 | 13.3 | 27.5 | 39 | 8 |
| 12. | 1<br>2-4<br>5 | LA 3#; LS 2 gal.; L3#<br>LA 3#; Bord.1/2-1-100<br>LA 3#; Bord. 2-4-100 | 11,499 | 35.2 | 42.5 | 0.4 | 3.5 | 4 | 62 |

1/ LA - lead arsenate
LS - lime sulfur
Mic.Pheno. - Micronized phenothiazine (Conditioned- or Unconditioned)
GAP - Ground apple pomace (60-mesh)
L - lime
Bord. - Bordeaux

Table 2.--Results of field experiments with insecticides for codling moth control - Stewart Orchard - Kearneysville, W. Va. - 1942

| Treat-ment No. | Cov-ers | Materials 1/ (Amounts per 100 gal.) | Total fruits | Percent inj. fruits: 1st brood | Percent inj. fruits: Har-vest | Percent wormy frts.: 1st brood | Percent wormy frts.: Har-vest | Total harvest injuries per 100 fruits: Worms | Total harvest injuries per 100 fruits: Stings |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1<br>2-5 | LA 3#;LS 2 gal.; L3#<br>LA 3#;Bord. 1/2-1-100 | 9,638 | 47.2 | 81.9 | 3.1 | 21.9 | 35 | 237 |
| 2 | 1<br>2-4<br>5 | LA 3#;LS 2 gal.; L 3#<br>Mic.Pheno.(Uncond.)2#<br>LA 3#;Bord. 2-4-100 | 12,173 | 22.7 | 70.3 | 6.7 | 43.5 | 80 | 106 |
| 3 | 1-5 | Mic. Pheno.(Uncond.) 2# | 9,705 | 16.9 | 45.4 | 8.6 | 37.5 | 59 | 17 |
| 4 | 1<br>2-4<br>5 | LA 3#; LS 2 gal.; L 3#<br>Mic. Pheno.(Cond.) 2#<br>LA 3#; Bord. 2-4-100 | 13,349 | 23.4 | 62.9 | 4.2 | 30.3 | 50 | 94 |
| 5 | 1-5 | Mic. Pheno. (Cond.) 2# | 12,167 | 15.0 | 43.5 | 6.9 | 33.8 | 53 | 16 |
| 6 | 1-4 | Mic. Pheno.(Uncond.) 2# | 12,856 | 14.2 | 48.9 | 6.6 | 41.2 | 67 | 17 |
| 7 | 1-5 | Mic. Pheno.(Uncond.) 3# | 10,411 | 8.6 | 34.9 | 2.8 | 29.3 | 47 | 10 |
| 9 | 1<br>2<br>3-5 | LA 3#; LS 2 gal.; L 3#<br>LA 3#; Bord.1/2-1-100<br>LA 3#; GAP 24#; Bord. 1/2-1-100 | 13,503 | 55.4 | 85.4 | 3.1 | 21.1 | 32 | 268 |
| [illegible] | 1-5 | Mic. Pheno. (Uncond.) 2#; Stove oil 1 qt.; Soap 1-1/2# | 13,127 | 30.2 | 58.7 | 14.6 | 50.3 | 87 | 25 |
| 12 | 1<br>2-4<br>5 | LA 3#; LS 2 gal.;L 3#<br>LA 3#; Bord. 1/2-1-100<br>LA 3#; Bord. 2-4-100 | 6,901 | 47.9 | 80.4 | 1.6 | 25.1 | 42 | 254 |

---

1/ LA - lead arsenate
LS - lime sulfur
Mic. Pheno. - Micronized phenothiazine (Conditioned - or Unconditioned)
GAP - Ground apple pomace (60-mesh)
L- lime
Bord. - Bordeaux

Unconditioned micronized phenothiazine at 3 pounds per 100 gallons (No. 7) was superior in effectiveness to all other combinations of that material used. In both orchards it resulted in considerably fewer injured fruits than the standard lead arsenate schedule (No. 1) following application of 4 first brood cover sprays and also at harvest. However, it allowed slightly more wormy fruits than the standard treatment, especially in the more heavily infested Stewart orchard. In both orchards, the unconditioned phenothiazine at 3 pounds gave distinctly better results than the same material at 2 pounds (No. 3), and approximately the same results were obtained with the 2 pound dosage used in 4 cover sprays (No. 6) as when the additional cover was applied. Very little difference resulted between treatments in which the conditioned and unconditioned phenothiazine was used. Split schedules, in which the phenothiazine was used in only 3 of the covers (Nos. 2 and 4) were no more effective than those treatments in which phenothiazine was used alone in 5 covers. The addition of stove oil and soap (No. 11) reduced the efficiency of the phenothiazine slightly.

Despite its tendency to permit a heavy carryover of worms, phenothiazine appears to have considerable merit as a codling moth insecticide. In the lead arsenate plot (No. 1) in the Stewart orchard few of the fruits would have been able to make U. S. No. 1 grade due to multiple stings, poor finish, and lack of good color. However, a high percentage of the phenothiazine-sprayed fruits fell into the U. S. No. 1 grade. Regular inspection by the West Virginia Inspection Service of one bushel of fruit from trees that received treatments Nos. 1 and 7 produced the following grade figures:

| Orchard | Treatment | % C. M. Inj. Fruit | % of Fruit in U. S. No. 1 Grade |
|---|---|---|---|
| Gatrell | No. 1 | 43.78 | 92.00 |
| Gatrell | No. 7 | 6.15 | 97.50 |
| Stewart | No. 1 | 81.87 | 26.50 |
| Stewart | No. 7 | 34.85 | 92.00 |

These figures are sufficiently accurate to indicate a strong disposition to favor the phenothiazine in packing quality. This is particularly true in the heavily infested Stewart orchard where the grower, had he used phenothiazine, would have been able to pack over three times as much quality fruit. The fruits were not graded for color and finish, but had this been the case the phenothiazine would have appeared even more superior in respect to grade.

The addition of ground apple pomace to the last three covers (No. 9) of the standard lead arsenate treatment failed to increase the efficiency of the insecticide.

## Reduced Lead Schedule

With present indications pointing toward a possible reduction in the amount of lead arsenate which will be available for insecticidal use, it is important to know how the supply can be used most effectively. With this in mind experimental schedules with reduced dosages of lead arsenate were tested. The schedules and the results obtained are shown in Table 3. An arbitrary figure of 50 per cent of the present recommendation of lead arsenate was used as a basis. All treatments resulted in a much higher degree of control than was expected; this was doubtless due to thoroughness and timeliness of applications.

Table 3.--Results of Experiments with Reduced Dosages of Lead Arsenate and Other Insecticides for Codling Moth Control, Fairview Orchard, Kearneysville, W. Va. - 1942

| Treatment No. | Materials 1/ and Applications (Amounts per 100 gallons) | Total fruits | Percent inj. fruits |  | Percent wormy fruits |  | Total harvest injuries per 100 Fruits |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  | 1st Brood | Harv. | 1st Brood | Harv. | Worms | Stings |
| 1 | LA 3# (Calyx and 5 covers) | 40,339 | 18.1 | 20.9 | 10.8 | .54 | 0.6 | 29 |
| 2 | LA 1-1/2# (Calyx and 5 covers) | 50,303 | 20.4 | 25.9 | .43 | 1.82 | 2.2 | 37 |
| 3 | LA 3# (Calyx and 4 covers) | 44,180 | 21.3 | 29.0 | .69 | 3.54 | 4.8 | 39 |
| 4 | LA 3# (Calyx and 3 covers) | 41,537 | 19.8 | 23.3 | .32 | 4.30 | 5.9 | 38 |
| 5 | LA 1-1/2# (Calyx and 3 covers) | 45,288 | 22.1 | 27.1 | .42 | 4.47 | 6.3 | 37 |
| 6 | LA 3# (3 covers only) | 31,652 | 21.4 | 30.5 | .42 | 3.36 | 4.6 | 43 |
| 7 | LA 3# (Calyx and 2 covers) | 36,203 | 17.7 | 23.5 | .49 | 3.72 | 4.9 | 32 |
| 8 | LA 3# (2 covers only) | 37,822 | 24.6 | 31.4 | 1.76 | 6.87 | 10.2 | 44 |
| 9 | LA 3# (3 covers only) Oil-nicotine (2nd. cover) Oil (3rd cover) | 40,018 | 13.6 | 22.7 | .10 | 2.00 | 2.5 | 31 |
| 10 | LA 3# (2 covers only) Oil-nicotine (2nd. cover) | 36,014 | 20.2 | 23.0 | .20 | 3.66 | 5.1 | 39 |
| 11 | LA 1-1/2# (Calyx and 1st cover) LA 3# (2nd cover) | 45,180 | 25.2 | 33.0 | 1.61 | 7.48 | 12.4 | 48 |

1/ LA - lead arsenate

Treatments Nos. 1, 3 and 4 are standard schedules as recommended for orchards supporting various degrees of codling moth infestations. The degree of codling moth control effected was in direct proportion to the number of cover spray applications or to the total amount of arsenate of lead used during the season.

Treatment No. 2 was in direct comparison with No. 1. In this treatment the amount of lead arsenate used in all sprays was reduced 50 per cent or to 1-1/2 pounds per 100 gallons. The control resulting from this treatment was somewhat less than for treatment No. 1 but better than for either Nos. 3 or 4. Each of these latter treatments, however, received a total of more lead arsenate than did No. 2. From this it would appear that less lead arsenate applied in more applications is more effective than more of the material used in fewer applications.

Treatments Nos. 6, 7 and 9 each received the same total amount of lead arsenate as No. 2 but only No. 9 gave control equivalent to that of No. 2. In No. 6 the lead was omitted from the petal-fall application and applied in three first brood applications. In No. 7 the lead was used in the petal-fall and two first brood applications. In No. 9 the lead was again omitted from the petal-fall application and added in three first brood applications but oil and nicotine were added in the second cover and oil in the third cover. Comparing treatments Nos. 6 and 7 there would appear to be but little difference in the control when lead is omitted from the petal-fall but used in three cover sprays or when it is used in the petal-fall and in only two cover sprays. Similar results were obtained when the total amount of lead arsenate was still further reduced and applied only in two first brood applications (Nos. 8 and 11), and with the oil and nicotine added only in the second cover (No. 10).

3. Codling Moth Population Build-up Studies.

Three main problems are being studied under this project:

1. The practicability of completely defruiting an apple orchard with toxic sprays under commercial conditions.

2. The rapidity of codling moth buildup in a completely isolated orchard following a year of complete fruit failure.

3. The effect of defruiting on lightly bearing blocks within orchards thus eliminating the necessity of subsequent sprays.

The work was performed in an isolated orchard near Nipetown, W. Va. It is located on Frankstown loam soil, is 8 acres in size, and consists mainly of York trees about 35 years old. In 1941 the orchard was pruned, fertilized and sprayed with lime-sulphur through the petal-fall spray only. By the close of the season it was in good commercial vigor. Infestation records were taken on 1,383 bushels of fruit and showed a total infestation of 48.5 per cent.

Defruiting sprays were applied in the spring of 1942. The spray used consisted of 1-1/2 gallons of 66 per cent home-made oil emulsion and 1/3 pound of 40 per cent DNOCHP per 100 gallons of water, applied between the pre-pink and petal-fall stages, April 17 to 30, 21,200 gallons of spray being applied. Of interest was the rapid recovery of the trees, which appeared as though seared by fire following treatment. Close examination showed some dead fruit spurs on Grimes but not sufficient to be of commercial importance. Yorks were almost entirely free of spur injury.

All trees were carefully examined on three occasions for fruit set. A total of 216 York trees yielded an average of only 5.1 fruits per tree, and no fruits were found on 104 of these. One tree in the orchard produced 157 fruits, thus materially increasing the average.

The results obtained can be considered as highly successful from the view point of crop elimination. It is planned to maintain infestation records annually for the next 5 years in order that codling moth build-up can be measured. The orchard will not be sprayed beyond petal-fall during this period.

### 4. Biological-Mechanical Control.

No significant changes were made in the project concerning the biological and mechanical control of the codling moth. The work was begun in 1935 and a virtually non-spray program has been practiced. The previous seven years have already been reported on. Further records obtained this year are summarized briefly, as follows:

The average yield of fruit per count tree, 2,032 apples, was below the 8-year average of 2,723 fruits. The percentages of wormy, stung and wormy, and stung fruits were respectively 39.7, 38.4, and 5.4 as compared to averages of 43.8, 16.4, and 5.0 percent, respectively, for the eight-year period 1935-42, inclusive. The larval parasitism (4.7 percent) was double that of the previous year and approximately the same as the average of the 8 years (4.6 percent). The percentage of larvae destroyed by predators (4.8) remained low in comparison to the 8-year average (7.2). The total crop, 2,538 bushels, was the lowest yield on record. The average crop for the period 1936-42, inclusive, was 4,328 bushels. Sixty percent of the crop dropped in comparison with a 55.3 percent drop during the abovementioned 7-year period. Codling moth injury was 93.3 percent in the drops, 68.8 percent in the harvested fruit, and 83.5 percent in the total fruits as compared to averages of 79.0, 47.8, and 64.7 percent, respectively, for the period 1935-42, inclusive.

Records in 1941 indicated that 60 trees with chemically treated bands caught an average of 430 larvae per tree as compared to an average of 347 larvae per tree caught on 60 trees with untreated bands. Similar records in 1942, however, showed an average catch of only 177.0 larvae per tree with the treated bands as compared to 191.6 larvae per tree captured by the untreated bands. Of 10,619 larvae recovered in November 1942 from treated bands on 60 trees, 9,731 (91.6 percent) were dead, 497 (4.7 percent) were discolored, and 391 (3.7 percent) were alive and apparently normal.

A comparison of different baits and different bait traps was again made in this orchard. In the double quart jar trap, standard brown sugar syrup bait trapped an average of 32.2 moths per trap in comparison with an average of 34.2 moths trapped with a table molasses base bait. The four quart stew pan trap was again outstandingly superior to the double jar trap and caught an average of 154.9 moths per trap with the table molasses base bait.

## VINCENNES, INDIANA

L. F. Steiner, In Charge [1]

### Seasonal Conditions and Codling Moth Development

Although sub-zero temperatures in January killed from 20 to 40 percent of the hibernating population in various orchards (a very high mortality for this region) a larger than normal population survived.

Rainfall in April and May was considerably below normal but in June it ranged from 8.83 to 9.11 inches in 4 locations, exceeding normal by more than 100 percent. In July it exceeded normal by 2 inches but August, September, and October were dry with deficiencies of 55, 81 and 66 percent respectively.

High temperatures in April accelerated development and moth emergence began in Vincennes orchards on April 27. Eggs began hatching not later than May 12. Emergence in cages held under orchard conditions passed the 50 percent point on May 10, the 75 percent point 3 days later, and the 90 percent point on May 30. Bait trap catches in 3 orchards reached a sharp peak on May 13.

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[1] All chemical analyses reported herein were made by or under the direction of J. E. Fahey, Division of Insecticide Investigations.

The daily mean temperature averaged 63.5° F. from May 2 to 13 inclusive and 63.8° F. from May 14 to 28. The minimum incubation period approximated 12 days until May 28. Growers using ovicides in their 2nd, 3rd and 4th covers therefore had two chances to kill the eggs laid during the peak flight period since sprays were being applied at 7- to 10- day intervals. The hatch of many eggs was delayed until the warm period of May 29 to June 7 during which the daily mean temperature averaged 81° F. The hatch was extremely heavy for a few days during this period but the turn to favorable weather came too late to permit much additional oviposition and injury rapidly tapered off in June.

The first brood infestation was lighter than usual in most well sprayed orchards but heavy in those which were poorly cared for. Mature larvae began leaving apples not later than June 9 and adults of the first-brood were found on June 23. Bait traps made their largest catches of this brood during the period from July 10 to 18. The largest one-day catch in 60 traps distributed in 3 orchards was only 165 moths, however, compared to 1,200 during spring-brood flight.

Second-brood larvae began hatching before July 1 and injury to fruit increased steadily throughout July, August and Early September. Moths of the second brood were coming to traps in their largest numbers during the last week in August. This brood was approximately the same size as the preceding. Trap catches practically ceased by September 16 although fresh injuries were abundant in parts of some orchards until September 20. The present carryover of hibernating larvae is below normal throughout most of Southern Indiana, Illinois and Northwestern Kentucky. The light crop, early tapering off of third-brood attack, and more thorough application of control measures because of better prices were largely responsible.

## Laboratory Experiments with Insecticides

In the report for 1941 attention was called to the finding that crude soybean phosphatides could be used in making deposit-building spray mixtures containing nicotine-bentonite or lead arsenate. During early 1942 an intensive study of the material was made in some 300 mixing and spraying tests. Since a preliminary report will appear as a scientific note in an early issue of the Journal of Economic Entomology the results will not be included here.

Other laboratory tests utilizing 112,000 newly hatched larvae were conducted in June, November and December. In some of these tests the soybean phosphatides (when used in insufficient quantities to give the mixtures deposit building properties) effected substantial increases in efficiency through improved spreading properties. The material is very promising as a spreader. Run-off is not increased to the extent characteristic of most spreaders and the action is not affected by water hardness.

Results of tests with a few of the most promising of more than 200 formulas tested are given in table 1. Treatments in different experiments are not directly comparable although the percent larvicidal efficiency is calculated on the basis of successful entrances in treated fruit as compared to those in an unsprayed check in each experiment. The difference required for significance at 5 percent odds within each experiment is given. From 40 to 60 apples and from 400 to 600 newly hatched larvae were used for each efficiency determination. Twenty extra apples were sprayed for deposit analyses. All sprays were applied by an orchard type sprayer converted to laboratory use. In these tests the type of deposit was often more important than the amount in determining effectiveness.

Table 1. Larvicidal efficiencies and spray deposits obtained with certain spray mixtures in laboratory experiments. Vincennes, Ind. 1942

| Experiment Number | Materials per 100 gals. | Percent efficiency | $As_2O_3$ or nicotine deposits in mmg. per cm.$^2$ |
|---|---|---|---|
| 962 - 1. | 0.5 pt. nicotine sulfate, 2.5 lb. Wyo. bentonite, 1 pt. soybean oil (1/2 standard tank mix) | 71.9 | 3.7 |
| 2. | Same as 1 except 8 oz. crude phosphatides and 1 pt. kerosene replaced soybean oil | 78.4 | 4.1 |
| 3. | 1.5 lb. micronized dry-mix[1] nicotine bentonite, 1 qt. mineral oil | 76.1 | 1.7 |
| 4. | Same as 3 except mineral oil replaced by 1 qt. kerosene, 6 oz. crude phosphatide and 4 oz. zinc sulfate | 94.4 | 1.8 |
| 5. | 3 lb. lead arsenate, 0.75 lb. $CuSO_4$, 1.5 lb. lime | 34.8 | 12.5 |
| 6. | Same as 5 + 8 oz. crude phosphatide | 55.4 | 9.9 |
| 7. | Same as 5 + 6 oz. Colloidal 77-C | 37.6 | 8.0 |
|  | Least significant difference | 10.6 |  |

Table 1. - continued

| Experiment Number | Materials per 100 gals. | Percent efficiency | $As_2O_3$ or nicotine deposits in mmg. per $cm.^2$ |
|---|---|---|---|
| 967 - | 1. 2.5 lb. micronized dry mix, 1 qt. soybean oil (3% crude phos.) | 89.1 | 3.1 |
| | 2. 2.5 lb. micronized dry mix, 1 qt. mineral oil | 79.6 | 2.3 |
| | 3. No. 2 + 1 oz. aluminum sulfate | 78.6 | 2.5 |
| | 4. No. 2 + 1 oz. zinc sulfate | 89.5 | 2.6 |
| | 5. No. 2 + 4 oz. soybean flour | 74.9 | 2.1 |
| | 6. No. 2 + 4 oz. crude phosphatide | 91.8 | 2.8 |
| | 7. No. 2 + 1 oz. acetone insoluble fraction of crude phosphatide | 93.5 | 3.0 |
| | Least significant difference | 7.1 | |
| 969 - | Tank mixtures of 0.5 pt. nicotine sulfate and 4 lb. X110 2/ bentonite with the following supplements: | | |
| | 1. 2 qt. mineral oil (emulsive type) | 91.9 | 2.2 |
| | 2. No. 1 + 8 oz. crude phosphatide and 4 oz. zinc sulfate | 96.0 | 5.4 |
| | 3. 1 qt. mineral oil (emulsive type), 8 oz. crude phosphatide, 4 oz. zinc sulfate | 96.7 | 4.2 |
| | 4. 2 qt. mineral oil (raw oil), 8 oz. crude phosphatide, 4 oz. zinc sulfate | 94.9 | 4.6 |
| | 5. 1 qt. soybean oil, 8 oz. crude phosphatide, 4 oz. zinc sulfate | 86.8 | 11.2 |
| | 6. As No. 5 except crude phos. from another source used | 97.4 | 4.1 |
| | Least significant difference | 2.7 | |

Table 1 - continued

| Experiment Number | Materials per 100 gals. | Percent efficiency | $As_2O_3$ or nicotine deposits in mmg. per cm.$^2$ |
|---|---|---|---|
| 982 - | LA (lead arsenate, 4 lbs.), Lime (2 lbs.). Bdx. (copper sulphate 3/4 lb. + lime 1-1/2 lb.) Mineral oil (2 qts. emulsive type) AIF (acetone insoluble fraction of crude phosphatides) | | |
| | 1. LA, lime, 4 oz. soybean flour | 59.0 | 10.4 |
| | 2. LA, lime, 1 oz. AIF | 73.9 | 10.9 |
| | 3. LA, lime, 3 oz. AIF | 78.7 | 9.5 |
| | 4. LA, lime, 5 oz. AIF | 80.3 | 9.5 |
| | 5. No. 2 with mineral oil | 86.8 | 15.6 |
| | 6. No. 3 with mineral oil | 87.2 | 17.2 |
| | 7. No. 4 with mineral oil | 90.0 | 17.6 |
| | 8. LA, Bdx, 4 oz. soybean flour | 55.0 | 8.5 |
| | 9. LA, Bdx, 1 oz. AIF | 49.4 | 11.8 |
| | 10. LA, Bdx, 3 oz. AIF | 53.8 | 9.1 |
| | 11. LA, Bdx., 5 oz. AIF | 58.2 | 8.7 |
| | 12. No. 9 with mineral oil | 55.4 | 15.5 |
| | 13. No. 10 with mineral oil | 68.7 | 14.0 |
| | 14. No. 11 with mineral oil | 73.1 | 11.7 |
| | Least significant difference | 8.7 | |

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1/ Made by mixing nicotine sulfate and powdered Wyoming bentonite in dust mixer at rate of 1 pt. per 5 lb., following which it was dried and micronized. The nicotine content was 9.0% and average particle size 1.6 microns.

2/ An untreated Mississippi bentonite having a low swelling value.

Other laboratory tests were conducted from which the following conclusions were drawn.

The order of mixing nicotine sulfate, mineral oil and two Mississippi bentonites (Panther Creek and X110 brands) had an important effect on results. Agitation of the bentonite with tap water for 5 minutes before addition of the other ingredients significantly reduced the efficiencies but increased the deposits. Best results were obtained with both by adding either the bentonite or nicotine sulfate to the water first and the oil last with no more than a 15 second lapse between additions.

Organic oils such as crude soybean oil, corn oil, and herring oil gave significantly higher efficiencies than mineral oils in formulas containing nicotine sulfate and either of the Mississippi bentonites. Soybean oil was significantly superior to corn oil or herring oil in the X110 formulas but not where the Panther Creek bentonite was used. Soybean oil was also superior to mineral oils as a supplement for dry mixtures (1 pt. nicotine sulfate to 10 lb. bentonite) made up with either of the Mississippi bentonites or the Wyoming bentonite. The 3 bentonites proved equally effective in "dry-mix" formulas when used with the same supplements. With mineral oil as a supplement the 1:10 dry mixes made from Mississippi bentonites did not decline significantly in efficiency after artificial weathering tests whereas the Wyoming bentonite formula dropped from 71.5 to 54.3 percent. The latter with soybean oil dropped only from 89.9 to 83.2 percent in efficiency.

Three pounds of lead arsenate per 100 gallons when added to tank mixtures of nicotine sulfate and bentonites from Mississippi, Georgia, and Wyoming as well as factory-processed nicotine bentonite in all cases reduced the efficiency.

Evidence was obtained that an extremely hard water (440 ppm. soap hardness test) used in some of the field tests was reducing effectiveness of the standard tank mix formula by increasing the proportion of soluble nicotine. The ratio of soluble to insoluble nicotine had little effect on initial deposit and efficiency, however. For use as spreaders and to a certain extent as deposit builders soybean phosphatides can be used with good results in the dry form after extraction of the oil by acetone in which condition they can be readily mixed with water, or in water mixtures preserved with benzoate of soda, or in the crude form. About 4 to 6 ounces of the crude form are required to equal 1 ounce of the dry material. Crude phosphatides from some sources can be wet with water by strong agitation, but other brands must be mixed with oil before their addition to the spray mixture.

## Laboratory-field Experiments

The method used in conducting these experiments has been described in previous reports and is outlined in detail in multigraphed circular E-488 (September, 1939). The trees used for most of the tests were of the Grimes Golden variety, 20 to 22 years of age, and required an average of approximately 26 gallons per tree for thorough coverage.

Prebloom and petal-fall sprays were applied for control of apple scab. The petal-fall sprays were applied on April 28 and 29 and consisted of: 3 lb. lead arsenate, 3 lb. lime, and 5 lb. wettable sulfur per 100 gallons.

Cover sprays were applied on the following dates:

| Spray Number | Orchard 1 | Orchard 2 |
|---|---|---|
| 1 | May 11 | May 12 |
| 2 | May 19 | May 22 |
| 3 | May 27 | June 1 |
| 4 | June 5 | June 9,10,11 |
| 4a (Top-off) | June 17 | - |
| 5 | July 3 | June 29 |
| 6 | July 20,21 | July 14 |
| 7 | Aug. 5 | July 28 |
| 8 | - | Aug. 19 |

In this report space does not permit presentation of the data so as to show the effects of individual spray applications, rains, prolonged interspray periods, drought conditions, etc., or the degree of larvicidal protection present at critical periods. Data from the more important plots have been averaged, however, so that the approximate relative effectiveness can be observed for the two periods during the growing season and at harvest.

Experiments in Orchard 1

Treatments and results for Orchard 1 are given in Table 2. A list of abbreviations used to indicate the spray materials included in the treatments shown in that and subsequent tables follows:

LA (lead arsenate)
Nic. (nicotine sulfate, 40%)
Xan. (xanthone)
FPNB (factory processed nicotine bentonite, 14%)
CaB (calcium arsenate & bentonite, 50:50)
C-77 (Colloidal 77)
CP (crude soybean phosphatides)
Pheno. (micronized phenothiazine)
C. Pheno. (micronized conditioned phenothiazine)
L (lime)
ZS (zinc sulfate)
X110 (Mississippi bentonite)
Bdx(1/2)(1/2:1:100 bordeaux mixture)
Bdx (3/4)(3/4:1-1/2:100 bordeaux mixture)
WB (Wyoming bentonite)
DM 1:10 (dry mix, 1 pt.nic. to 10 lb.WB)
DM 1:5 (dry mix, 1 pt.nic.to 5 lb. WB)
MDM (a micronized 1:5 dry mix, 9% nic.)
Ker. (kerosene)
371 oil (a raw mineral oil of 82% U.R. and 72 visc.)
MO (an emulsive 97% mineral oil of 92.8% U.R. and 57.6 visc.)
SO (crude soybean oil)
SF (soybean flour)
Cry. (synthetic cryolite)
ARF (alkali refining foots)
F (ferric dithiocarbamate)

Table 2.-Average percent larvicidal efficiencies and spray deposits.
Orchard No. 1. Vincennes, Indiana. 1942

| Plot | Cover sprays | Materials per 100 gallons | Residues[1] | May 18-July 1: Before sprays | May 18-July 1: After sprays | July 3-Aug.5: Before sprays | July 3-Aug.5: After sprays | Harvest Sept. 2 |
|---|---|---|---|---|---|---|---|---|
| Lead arsenate plots | | | | | | | | |
| 1 | 1,4a | 4 lb. LA, Bdx.(3/4) | | | | | | |
| | 2-4 | 4 lb. LA, Bdx.(3/4), 2 qt. 371 oil | | 38.9 | 50.8 | 74.7 | 71.9 | 71.1 |
| | 5-7 | 3 lb. LA, Bdx.(3/4) | $As_2O_3$ | (15.4) | (24.4) | (15.2) | (24.0) | (16.9) |
| 2 | 1 | 4 lb. LA, Bdx.(3/4) | | | | | | |
| | 2,4a | 3 lb. LA, Bdx.(1/2), 1 lb. CP, 2 qt. Ker.[2] | | 38.3 | 59.2 | Discontinued | | |
| | 3,4 | 3 lb. LA, Bdx (1/2), 1 lb. CP, 2 qt. 371 oil[2] | $As_2O_3$ | (12.8) | (19.4) | | | |
| 3 | 1 | 4 lb. LA, 1/2 lb.ZS, 1 lb. L. | | | | | | |
| | 2,4a | 4 lb. LA, 1/4 lb.ZS, 1/2 lb. L., 1 lb. CP, 2 qts. Ker.[2] | | | | | | |
| | 3,4 | 4 lb. LA, 1/4 lb.ZS, 1/2 lb.L, 1 lb. CP., 2 qts. 371 oil[2] | | 37.1 | 56.6 | 71.6 | 72.6 | 67.3 |
| | 5-7 | 3 lb. LA, 3/4 lb.ZS, 1-1/2 lb. L | $As_2O_3$ | (11.6) | (17.4) | (12.6) | (22.2) | (16.1) |
| 4 | 1 | 4 lb. LA, Bdx.(3/4) | | 34.7 | 57.5 | Discontinued | | |
| | 2-4a | 3 lb. LA, 1 qt. SO[2] | $As_2O_3$ | (12.0) | (17.0) | | | |
| 5 | 1 | 4 lb. LA, Bdx.(3/4) | | | | | | |
| | 2-4 | 3 lb. LA, 4 oz.C-77, 1 qt. 371 oil[2] | | | | | | |
| | 4a | 3 lb. LA, 4 oz.C-77, 1 qt. Ker.[2] | | 37.0 | 61.3 | 77.2 | 75.1 | 68.5 |
| | 5-7 | 3 lb. LA, 4-6 oz.C-77, Bdx.(3/4) | $As_2O_3$ | (13.2) | (20.0) | (14.5) | (23.6) | (18.4) |
| Split schedule or combination treatments | | | | | | | | |
| 5a | 1-4a | Same as Plot 5 | | | | 55.2 | 59.5 | 38.0 |
| | 5-7 | 2 lb.Cry., 1 lb.CP, 1 qt. MO | $As_2O_3$ | | | (8.9) | | (5.9) |

Table 2. - continued

| Plot | Cover sprays | Materials per 100 gallons | Residues 1/ | May 18-July 1 Before sprays | May 18-July 1 After sprays | July 3-Aug. 5 Before sprays | July 3-Aug. 5 After sprays | Harvest Sept. 2 |
|---|---|---|---|---|---|---|---|---|
| 6 | 1,2 | Same as Plot 1 | | | | | | |
| | 3-4a | 2 lb. LA, 1 lb. Xan., 1/4 lb.ZS, 1/2 lb.L, 1 lb. CP, 2 qt.Ker. | | 29.5 | 55.5 | 57.0 | 71.7 | 63.2 |
| | 5-7 | 2 lb. LA, 1 lb. Xan., 1 lb.ZS, 2 lb. L. | $As_2O_3$ | (11.1) | (15.6) | (7.0) | (11.5) | (8.5) |
| 7 | 1-4a | 2 lb. LA, 1 lb.Pheno., 1/2 lb.ZS, 1 lb.L, 4 oz. SF | $As_2O_3$ | 22.6<br>(5.9) | 65.9<br>(9.6) | 59.2<br>(8.2) | 61.2<br>(14.8) | 68.7<br>(11.7) |
| | 5-7 | 3 lb. LA, 3/4 lb.ZS, 1-1/2 lb. L., 4 oz.SF | Pheno. | (2.2) | (8.2) | | | 0 |
| 8 | 1 | 4 lb. LA, Bdx.(3/4) | | | | | | |
| | 2,3 | 2 lb. LA, 2 lb.FPNB, 2 qts. 371 oil | | | | | | |
| | 4,4a | 2 lb. LA, 1-1/2 lb. FPNB, 2 qts 371 oil | | 32.1 | 49.6 | 55.4 | 69.0 | 48.6 |
| | 5 | 2.3 lb. FPNB, 1 qt.MO | $As_2O_3$ | (10.9) | (15.2) | (6.7) | (6.7) | (5.0) |
| | 6-7 | 2.3 lb. FPNB, 2 qt. MO | Nicotine | (1.5) | (1.8) | (0.9) | (2.6) | (1.0) |
| Nicotine-bentonite plots | | | | | | | | |
| 10 | | Standard tank mix | | | | | | |
| | 1-4a | 1 pt.Nic., 5 lb.WB, 1 qt. SO | | 65.8 | 83.2 | 76.8 | 88.4 | 79.9 |
| | 5-7 | 2/3 pt.Nic., 3.3 lb. WB, 1 qt. SO | Nicotine | (3.7) | (6.6) | (2.8) | (5.7) | (3.0) |
| 10a | 1,2 | 1 pt.Nic., 5 lb.WB, 1 qt. SO | | | | | | |
| | 3,4a | 2 lb. FPNB, 1/3 pt. Nic., 2 lb.WB, 2 qt. 371 oil | | 60.7 | 78.4 | 74.6 | 88.0 | 72.2 |
| | 5-7 | Same as Plot 8 | Nicotine | (3.1) | (5.7) | (1.6) | (3.7) | (1.7) |
| 10b | 1-4a | Same as Plot 10 | | | | 82.1 | 94.3 | 84.0 |
| | 5-7 | 3-1/2 lb. MDM, 1 qt. SO | Nicotine | | | (2.4) | (4.9) | (2.5) |
| 10c | 1-4a | Same as Plot 10 | | | | 76.9 | 90.5 | 55.9 |
| | 5-7 | 2 lb. MDM, 4 oz.ZS, 8 oz.CP, 1 qt.Ker. | Nicotine | | | (1.8) | (3.6) | (1.5) |

Table 2. - continued

| Plot | Cover sprays | Materials per 100 gallons | Residues[1] | May 18-July 1 | | July 3-Aug. 5 | | Harvest Sept. 2 |
|---|---|---|---|---|---|---|---|---|
| | | | | Before sprays | After sprays | Before sprays | After sprays | |
| 10d | 1-4a<br>5-7 | Same as Plot 10<br>4 lb. DM 1:5, 1 qt. SO | Nicotine | | | 77.2<br>(1.8) | 91.9<br>(4.5) | 62.8<br>(1.8) |
| 10e | 1-4a<br>5-7 | Same as Plot 10<br>7 lb. DM 1:10, 1 qt. SO | Nicotine | | | 83.4<br>(2.6) | 92.5<br>(5.5) | 79.1<br>(2.6) |
| 10f | 1-4a<br>5<br>6-7 | Same as Plot 10<br>7 lb. DM 1:10, 1 qt. MO<br>7 lb. DM 1:10, 2 qt. MO | Nicotine | | | 82.2<br>(2.4) | 91.2<br>(6.0) | 77.8<br>(2.7) |
| Phenothiazine plots | | | | | | | | |
| 11 | 1-4a | 2 lb. Pheno. | Pheno. | 38.3<br>(6.0) | 80.3<br>(21.2) | Discontinued | | |
| 12 | 1-3<br>4,4a | 2 lb. Pheno.,4 oz. CP, 1 pt. Ker.<br>2 lb. Pheno., 4 oz. CP | Pheno. | 18.5<br>(4.3) | 64.0<br>(17.2) | Discontinued | | |
| 13 | 1-4a | 2 lb. C. Pheno. | Pheno. | 32.4<br>(5.9) | 76.2<br>(17.6) | Discontinued | | |
| Calcium arsenate plot | | | | | | | | |
| 14 | 1-4a | 4 lb. CaB | $As_2O_3$ | 8.2<br>(7.6) | 11.2<br>(12.9) | Discontinued | | |

[1] Deposits as mmg. per $cm.^2$ are shown by figures in parenthesis.

[2] Oil contained 5% oleic acid.

Although the formulas applied to Plots 2, 3, 4, 5, and 6 during the first-brood period had deposit-building characteristics the trees were not sprayed past the point of run-off. Because of the better spreading action, slightly less material was applied to each tree as a whole than used on Plot 1; however, some build-up was expected on those parts of the tree which had to be over-sprayed in order to wet more distant fruit. The Indiana-Illinois standard schedule, plot 1, was equal to the other lead arsenate treatments after periods of weathering but its fresh deposits, though heavier, were less efficient than the formulas in which the crude phosphatides were used. The phosphatides made possible a saving of one pound of lead arsenate per 100 gallons in 3 cover sprays and the 1 top-off spray. Crude raw soybean oil (unclarified) supplemented with 5 percent oleic acid will form a deposit building mixture with lead arsenate (the oil normally contains 2 to 3 percent crude phosphatides) if the agitation is properly adjusted. Its results on Plot 4 were not outstanding partly because the mixture "buttered out" in the tank during the second application. Colloidal-77 used on Plot 5 gave approximately the same results as the phosphatides on Plots 2 and 3 but this plot received no bordeaux mixture or lime between the first and fifth covers. A 3/4:1-1/2:100 zinc sulfate and lime mixture as a supplement for lead arsenate in second-brood sprays gave approximately the same results (Plot 3) as a weak bordeaux mixture (Plot 1).

Of the combination treatments tested the Plot 7 formula was most promising despite more than 9 inches of rainfall between May 28 and July 1. Although very susceptible to losses from weathering this lead arsenate-phenothiazine mixture (without oil) was more effective than the treatment for any non-nicotine plot immediately after the first-brood sprays. This was the only plot receiving lead or calcium arsenate that failed to show arsenical injury. Foliage injury and fruit russet was most severe on Plots 14, 2 and 6, with moderate injury appearing on Plots 3, 5, 4, 8, and 1 in descending order. Part of this injury was caused by the oil and spreaders used and the hot or very humid weather at the time of their application. The phenothiazine darkened the foliage but the color returned to normal by harvest.

After July 1 the formulas applied to Plots 8 to 10f inclusive, with the exception of 10c, contained equal quantities of nicotine (0.32 lb. per 100 gal.). During this period Plots 8 and 10a were sprayed from the same tank at each application and, as reported in previous years, lead arsenate residues appeared to depress the efficiency and toxicity of the nicotine-bentonite deposited over them. Standard tank mix nicotine bentonite (plot 10) was the most effective first-brood treatment but it proved slightly inferior after July 1 to a number of the variations designed to avoid objectionable residues at harvest. These included 10b, 10e, and 10f. Treatment 10c, with slightly more than half as much nicotine and supplemented with crude soybean phosphatides, was equal until near the end of the 4-week weathering period between the final cover spray and harvest. The regular dry-mix (Plot 10d) was also more susceptible to weathering toward the end of the season than the formulas used on other parts of Plot 10. The more dilute dry mix, however, appears very promising, particularly since when supplemented with soybean oil (10e) it was almost as effective as the micronized material (10b).

Fruit from all the nicotine plots except No. 10 was cleaned by dry brushing at harvest. Fruit from Plot 10 retained objectionable bentonite residues.

Plots 11, 12, and 13 were discontinued after the first-brood period. The regular micronized phenothiazine was significantly more effective than the conditioned micronized material after periods of heavy rains. It has a slightly greater adverse effect on color, however, and was more difficult to pulverize and wet than in previous seasons. Phenothiazine with the crude phosphatides and kerosene was too susceptible to weathering and its toxicity was reduced considerably by the supplements.

Calcium arsenate with bentonite (Plot 14) gave poor results and caused severe arsenical injury.

Ovicidal efficiency of certain treatments in Orchard No. 1: The importance and necessity for also considering the many factors other than larvicidal efficiency that contribute to control has been discussed in previous reports. Reliable data, however, are difficult to obtain. Laboratory tests of ovicides have been found to seriously overestimate the efficiency of oil sprays yet they greatly underestimate the ovicidal efficiency of xanthone.

The relative effectiveness of certain of the treatments applied in Orchard 1, against eggs deposited before and after the 4th and 6th cover sprays by moths caged in different parts of the trees, is shown in Table 3.

Table 3. Ovicidal efficiency of certain spray treatments. Orchard 1, Vincennes, Indiana. 1942

| Plot | Treatment[1/] | Time of deposition | 1 to 3 days before and 1 to 2 days after 4th cover spray | | 1 to 2 days before and 1 to 4 days after 6th cover spray | |
|---|---|---|---|---|---|---|
| | | | Total No. Eggs | Eggs dead Percent | Total No. Eggs | Eggs dead Percent |
| 1. | LA, Bdx., 1/2% mineral oil | Before spray | 1,758 | 69.7 | - | |
| | | After spray | 545 | 35.2 | - | |
| 2. | As above + crude phosphatide | Before spray | 1,321 | 57.8 | - | |
| | | After spray | 383 | 18.0 | - | |
| 5. | LA, C-77, 1/4% mineral oil | Before spray | 628 | 51.6 | - | |
| | | After spray | 896 | 25.0 | - | |
| 6. | LA + Xanthone | Before spray | 1,888 | 32.4 | 431 | 15.5 |
| | | After spray | 407 | 79.9 | 406 | 32.0 |
| 10. | STM (1/4% soybean oil) | Before spray | 3,810 | 6.8 | - | |
| | | After spray | 459 | 10.5 | - | |
| 10a. | STM + FPNB + 1/2% mineral oil | Before spray | 3,637 | 33.0 | 845 | 14.3 |
| | | After spray | 707 | 16.8 | 519 | 5.6 |
| 10f. | Dry Mix 1:10 + 1/2% mineral oil | Before spray | - | | 696 | 7.9 |
| | | After spray | - | | 747 | 9.9 |

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1/ For details see Table 2.

The results show that oils and xanthone were more effective in early June than in July, that nicotine bentonite reduces the effectiveness of 1/2 percent mineral oil to less than 50 percent of its effectiveness when used with lead arsenate and a weak bordeaux mixture, and that the crude phosphatides as used appeared to decrease rather than increase the ovicidal efficiency of 1/2 percent mineral oil.

Experiments in Orchard 2

This set-up consisted entirely of nicotine bentonite treatments. The most important results are given in Table 4.

Table 4.-Average percent larvicidal efficiencies and spray deposits. Orchard No. 2. Vincennes, Indiana. 1942.

| | | | Larvicidal efficiencies (percent) and nicotine residues 1/ | | | | |
|---|---|---|---|---|---|---|---|
| | | | May 21-June 23 | | June 29-Aug. 20 | | |
| Plot | Cover sprays | Materials per 100 gallons | Before sprays | After sprays | Before sprays | After sprays | Harvest |
| 29 | 1-4 | 1/2 pt.Nic., 5 lb.WB,1 qt.SO | | | | | |
| | 5-7 | 1/3 pt.Nic.,3.3 lb.WB,1qt.SO | 51.8 | 73.1 | 64.7 | 81.8 | 59.9 |
| | 8 | 1/3 pt.Nic.,1/2 lb.WB,2 qt. MO | (2.3) | (3.4) | (2.4) | (4.4) | (1.6) |
| 15 | | Standard tank mix | | | | | |
| | 1-4 | 1 pt.Nic.,5 lb.WB, 1 qt. SO | | | | | |
| | 5-7 | 2/3 pt.Nic.,3.3 lb. WB, 1 qt. SO | 70.1 | 86.8 | 82.0 | 92.1 | 76.7 |
| | 8 | 2/3 pt.Nic.,1/2 lb. WB, 2 qt. MO | (3.1) | (6.4) | (3.3) | (5.7) | (3.5) |
| 15a | 1-4 | Same as Plot 15 | | | | | |
| | 5 | 2/3 pt.Nic., 5 lb.X110, 1 qt. MO | -do- | -do- | 88.0 | 96.8 | 82.5 |
| | 6-8 | 2/3 pt. Nic., 5 lb.X110, 2 qt. MO | | | (2.9) | (5.8) | (3.0) |
| 15b | 1-8 | Same as Plot 15a, except 371 oil used in place of MO | -do- | -do- | 88.1<br>(2.9) | 95.7<br>(5.6) | 84.2<br>(3.2) |
| 15c | 1-8 | Same as Plot 15a, except 1 qt. SO used in place of MO | -do- | -do- | 85.1<br>(2.6) | 97.0<br>(5.2) | 72.3<br>(2.4) |
| 15d | 1-4 | Same as Plot 15 | | | | | |
| | 5 | 1/2 pt.Nic., 4 lb.X110,8 oz. CP, 4 oz.ZS, 1 qt. 371 oil | | | | | |
| | 6-8 | 1/2 pt.Nic., 4 lb.X110, 8 oz. CP, 4 oz.ZS, 2 qt. Mo. | -do- | -do- | 90.0<br>(3.2) | 96.1<br>(5.4) | 86.7<br>(3.6) |
| 15e | 1-4 | Same as Plot 15 | | | | | |
| | 5 | 2.3 lb. FPNB, 1 qt. MO | -do- | -do- | 80.2 | 90.4 | 72.3 |
| | 6-8 | 2.3 lb. FPNB, 2 qt. MO | | | (2.6) | (5.2) | (2.1) |

Table 4. - continued

| | | | Larvicidal efficiencies (percent) and nicotine residues 1/ | | | | |
|---|---|---|---|---|---|---|---|
| | | | May 21-June 23 | | June 29-Aug. 20 | | |
| Plot | Cover sprays | Materials per 100 gallons | Before sprays | After sprays | Before sprays | After sprays | Harvest |
| 16 | 1-4 | 1 pt.Nic., 5 lb.WB, 1-1/2 lb. ARF | 66.0<br>(3.1) | 82.6<br>(5.5) | 72.9<br>(1.7) | 92.8<br>(4.1) | 60.5<br>(1.4) |
| | 5-8 | 2/3 pt.Nic., 5 lb.X110, 1-1/2 to 1/2 lb. ARF | | | | | |
| 17 | 1-4 | Same as Plot 15 supplemented with 1-1/2 lb. F. | 62.4<br>(3.0) | 81.0<br>(5.9) | Discontinued | | |
| 18 | 1 | 6 lb.DM 1:5, 1 qt. 371 oil | 58.9<br>(2.1) | 76.0<br>(5.0) | Discontinued | | |
| | 2-4 | 6 lb.DM 1:5, 2 qt. 371 oil | | | | | |
| 19 | 1-4 | Same as Plot 18 except 1 qt.SO instead of 371 oil | 48.3<br>(2.6) | 73.4<br>(4.6) | Discontinued | | |
| 22 | 1-4 | 6 lb. MDM | 67.2<br>(2.6) | 86.9<br>(5.4) | 80.7<br>(2.3) | 93.2<br>(5.3) | 77.8<br>(1.9) |
| | 5-8 | 3-1/2 lb. MDM | | | | | |
| 23 | 1 | 6 lb. MDM | 78.9<br>(3.3) | 88.6<br>(5.8) | 92.8<br>(3.8) | 97.3<br>(6.6) | 90.6<br>(3.9) |
| | 2-4 | 6 lb. MDM, 2 qt. 371 oil | | | | | |
| | 5-8 | 3-1/2 lb. MDM, 1 qt. 371 oil, 4 oz. SF | | | | | |
| 24 | 1-4 | 6 lb.DM 1:10, 1 qt. SO | 58.7<br>(2.4) | 78.0<br>(3.6) | 84.3<br>(3.4) | 93.4<br>(6.0) | 86.1<br>(3.6) |
| | 5-8 | 7 lb.DM 1:10, 1 qt. SO | | | | | |
| 25 | 1 | 1 pt. Nic., 5 lb.X110, 1 qt. MO | 66.9<br>(2.6) | 86.3<br>(5.5) | 84.3<br>(2.7) | 94.4<br>(5.7) | 86.1<br>(2.0) |
| | 2 | 1 pt. Nic., 5 lb.X110, 2 qt. MO | | | | | |
| | 3,4 | 1 pt.Nic., 8 lb.X110, 2 qt. MO | | | | | |
| | 5 | 2/3 pt.Nic., 5 lb.X110, 1 qt. MO | | | | | |
| | 6-8 | 2/3 pt.Nic.,5 lb.X110, 2 qt.MO | | | | | |
| 27 | 1-4 | 1/2 pt.Nic.,3-1/2 lb.X110, 4 oz.ZS, 3 pt.SO, 3 oz. CP (Inverted by agitation) | 37.6<br>(1.8) | 61.4<br>(3.0) | Discontinued | | |

Table 4. - continued

| Plot | Cover sprays | Materials per 100 gallons | Larvicidal efficiencies (percent) and nicotine residues 1/ | | | | |
|---|---|---|---|---|---|---|---|
| | | | May 21-June 23 | | June 29-Aug. 20 | | |
| | | | Before sprays | After sprays | Before sprays | After sprays | Harvest |
| 28 | 1 | 1/2 pt.Nic.,4 oz.ZS, 8 oz. CP,3-1/2 lb. X110 | 49.8<br>(1.8) | 69.5<br>(3.1) | 74.9<br>(2.6) | 89.6<br>(4.8) | 68.8<br>(2.4) |
| | 2-4 | 1/2 pt.Nic., 4 oz. ZS, 8 oz.CP, 3-1/2-4 lb.X110, 2 qt. 371 oil | | | | | |
| | 5 | 1/2 pt.Nic.,4 oz.ZS, 8 oz. CP, 4 lb.X110, 1 qt. 371 oil | | | | | |
| | 6-8 | 1/2 pt.Nic.,4 oz.ZS, 8 oz. CP, 4 lb.X110, 2 qt.MO (All mixtures brought to breaking point by agitation of slurry) | | | | | |

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1/ Deposits as mmg. per cm.$^2$ are shown by figures in parenthesis.

During the preparation of the dry-mix material there was some loss of moisture. This resulted in some variation in nicotine content of the spray mixtures early in the season. For the second and third brood sprays all formulas were adjusted to provide 0.32 lb. of nicotine alkaloid per 100 gallons, except those used on Plots 15d and 28 which contained 0.24 lb., and that used on Plot 29 which contained 0.16 lb. For the first-brood sprays the nicotine content per 100 gallons was as follows:

Plots 15, 16, 17, 25 - 0.047 lb. (1 pt. nicotine sulfate)
28, 29 - 0.024 lb. (1/2 pt. nicotine sulfate)
18, 19, 22, 23 - 0.50 lb. (6 lb. Dry mix 1:5)
24 - 0.28 lb. (6 lb. Dry mix 1:10)

The most effective nicotine treatment found in recent years was included in Plot 15 as the standard. By halving the nicotine in this formula, following suggestions made by the Committee on Supply of Insecticides of the American Association of Economic Entomologists, worm survival was approximately doubled. (Plot 15 vs. 29). Worm entrances in the 16 samples taken from these plots averaged 26.3 percent for Plot 29 and 14.5 percent for Plot 15. The actual effectiveness of the half strength tank mix can be expected to depend entirely on the population density. Above a certain level enough larvae could escape first brood sprays in this region to provide a population in later broods that would completely destroy the crop.

Because of the high price of soybean oil, soybean or so-called alkali refining foots or soap stock which is high in phosphatide content was tested on Plot 16. This material proved to be an excellent spreader but it apparently had less adhesive action than soybean or mineral oil (Plots 16 vs. 15, 15a and 15c). It may be useful in more arid climates or where oils must be avoided.

The addition of the new fungicide, ferric dithiocarbamate, to the standard tank mix (Plot 17) caused a significant reduction in both initial and residual efficiency. This treatment was discontinued in mid-season because of the heavy black residue.

Plots 18 and 19 (Dry-Mix 1:5) were also discontinued. These treatments proved less effective than those in Plot 24 (Dry Mix 1:10) although the latter required less than 60 percent as much nicotine. Plot 27 was discontinued because the formula used deposited too granular a type of deposit.

The results in Plots 22 and 23 were in line with those obtained at this laboratory in 1940 and 1941 with a micronized factory processed material. Without any supplements (Plot 22) the material was equal to the standard tank mix formula after the sprays but appeared slightly more susceptible to weathering. When supplemented with mineral oil and later with 1/4 percent oil and 1/4 lb. soybean flour it proved outstanding. Apparently the micronizing process reduced this dry mix to a state approaching that of the original bentonite as regards adhesiveness although the swelling property was largely lost. The deposits were spotted and gave as much difficulty in removal at harvest as those on Plot 15.

The 1:10 dry mix treatment (Plot 24) proved slightly superior to the standard tank mix after it was used at an equivalent strength. Its bentonite residues were satisfactorily removed by brushing at harvest. The average particle size of this material was increased 40 percent above that of the original bentonite while that of the 1:5 mix increased 110 percent according to analyses by Mr. J. E. Fahey. The 1:10 dry mix also retained slightly more of its swelling value.

By the use of a Mississippi bentonite with a swelling value of approximately 1/4 that of Wyoming bentonite and with only a slightly lower capacity for removing nicotine from a water solution, a new tank mix formula was developed (Plot 25) utilizing mineral oil in place of soybean oil. It appeared equal to the standard mixture yet avoided the objectionable bentonite residues at harvest. This is the most important development in these tests of immediate use to growers. It appears necessary to use the bentonite at the rate of 7 to 8 pounds per pint of nicotine in order to obtain best results.

Another promising combination is that used on Plot 28 which, despite its apparent low efficiency, equalled the standard and new tank mix treatments in field tests.

The treatments used during the second- and third-brood periods on parts of Plot 15 (a, b, c, d, and e) were intended to utilize the high efficiency built up by the tank-mix in the first brood period, yet avoid objectionable bentonite residues at harvest. All were successful in the latter respect. The Plot 25 formula applied to Plot 15a gave better results, except at harvest, than it did on Plot 25. The Plot 28 formula (reduced strength with phosphatides) applied to 15d also gave better results following the tank mix than it did on Plot 28. Both were an improvement over the standard tank mix plot which received mineral oil and nicotine sulfate as its final spray.

The Mississippi bentonite with 1/2 percent raw mineral oil (15b) or with 1/4 percent soybean oil (15c) also proved equal or superior to the standard tank mix.

Plot 15e (factory processed nicotine bentonite and mineral oil) was slightly less effective than the standard tank mix and considerably less effective than the other Plot 15 variations. Its cost (for materials) was approximately 57 percent greater than that of Plot 15d and 48 percent more than 15b.

With the exception of Plot 28 which lost some foliage from oil injury no spray injury occurred from these treatments. Sooty blotch, however, was very prevalent on most plots, being somewhat more common on those which had been sprayed with crude phosphatides. It was conspicuously less common on Plots 15, 23 and 29 where bentonite residues were heaviest.

Ovicidal efficiency of certain treatments in Orchard 2: Ovicidal tests were conducted at the time of the third and seventh cover sprays.

As in Orchard No. 1, second-brood sprays were less effective as ovicides than first-brood sprays. The raw mineral oil as used on Plot 18 was nearly twice as effective as the emulsive type oil used on Plot 25, however, the former was used with 6 lb. per 100 gallons of a non-swelling bentonite and the latter with 8 lb. of a swelling type. The most important finding in these tests was that micronized nicotine bentonite used without supplements was of some value as an ovicide and, like xanthone, was more toxic to eggs laid after the application than to eggs laid before the spraying. The ovicidal efficiency of the Plot 28 treatment was no greater than that of Plot 25.

## Laboratory-field tests with various bentonites

During the latter part of the season single- tree plots were sprayed with various tank mix formulas made up with 4 different bentonites including two from Mississippi, one from Georgia, and the regular Wyoming bentonite. The two Mississippi bentonites were studied during the period from July 17 to Sept. 9 and were found equally effective. In tank mixtures of 1 pt. nicotine sulfate and 8 lb. bentonite they proved superior to the Georgia bentonite, the latter being used at 12 lb. per 100 gallons. Both soybean oil and mineral oil when included in the mixtures improved the results with the Mississippi bentonites, giving larvicidal efficiencies equal to those obtained with the standard tank mix. Both the Mississippi bentonites are untreated and are readily obtainable at less cost than the Wyoming types. It is probable that bentonites from a number of other sources will prove satisfactory.

## Small plot field tests

### Field tests of Insecticides on Randomized Plots

With slight changes in formulas the treatments numbered 1, 2, 5, and 6 in the Orchard No. 1 laboratory-field experiments and 15, 15a, 25 and 28 in Orchard No. 2 were repeated on Rome Beauty in a third orchard. These and 2 additional treatments were arranged in a restricted randomization on single-tree plots, each replicated 7 times. The experimental block was 2 rows wide and approximately one-half mile long and was bordered on two sides by Turley, Grimes and a few Rome Beauty trees. The experiments were located within a 200 acre orchard in a section where nearly 100 percent of the fruit was injured by codling moth in 1941 and within one-half mile of other Rome Beauty blocks in the same orchard which averaged 85 injuries per 100 apples in 1942. The acreage surrounding the plots was sprayed with a heavy lead arsenate-oil program by the owner.

Twenty bait traps distributed in the grower-sprayed trees along one side of the block caught approximately 3,500 moths of the spring brood and 2,750 moths of the later broods.

All plots were sprayed alike with calyx and calyx top-off sprays of 3 lb. lead arsenate, 3 lb. lime, and 6 lb. wettable sulfur per 100 gallons on April 30 and May 2. An extra spray of 3 lb. lead arsenate, 1.5 lb. lime and 4 lb. wettable sulfur was applied May 8.

All lead arsenate plots were given 7 cover sprays on May 13, 20, 29 and June 8, 30, July 15 and Aug. 3. The nicotine plots were given 8 cover sprays and 1 top-off: May 13, 21, 29, June 4 (top-off), 11, 30, July 15, Aug. 3 and 24. The trees required from 26 to 30 gallons each for thorough coverage. Approximately 12.5 gallons per tree were applied in the top-off spray to the upper one-third of the tree.

Table 5. - Results of small plot field tests. Vincennes, Ind. 1942

| Plot | Cover sprays | Materials per 100 gallons | Average per tree - June 24 |  | Seasonal data |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Worms | Stings | Apples per tree | Clean apples | Per 100 apples |  |
|  |  |  |  |  |  |  | Worms | Stings |
|  |  |  | (Number) | (Number) | (Number) | (Percent) | (Number) | (Number) |
| 1 | 1 | 4 lb.LA,Bdx (3/4) |  |  |  |  |  |  |
|  | 2-4 | Same plus 2 qt. 371 oil |  |  |  |  |  |  |
|  | 5-7 | 3 lb.LA,Bdx (3/4) | 9 | 125 | 3,197 | 83.8 | 5.3 | 18.8 |
| 2 | 1 | Same as Plot 1 |  |  |  |  |  |  |
|  | 2,3 | 3 lb.LA, Bdx (1/2) 8 oz.CP, 2 qt.Ker.[1] |  |  |  |  |  |  |
|  | 4 | 3 lb.LA,Bdx (1/2), 8 oz.CP,2 qt.371 oil [2] |  |  |  |  |  |  |
|  | 5 | 3 lb.LA,Bdx (3/4), 8 oz.CP |  |  |  |  |  |  |
|  | 6,7 | Same except 6 oz.CP | 27 | 470 | 3,928 | 84.4 | 3.9 | 18.0 |
| 3 | 1 | Same as Plot 1 |  |  |  |  |  |  |
|  | 2,3 | 3 lb.LA, 2 qt.371 oil,[2] 4 oz. C-77 |  |  |  |  |  |  |
|  | 4 | Same plus Bdx (3/4) |  |  |  |  |  |  |
|  | 5 | 3 lb.LA,Bdx (3/4), 4 oz. C-77 |  |  |  |  |  |  |
|  | 6-7 | Same except 6 oz. C-77 | 13 | 105 | 3,250 | 83.0 | 4.5 | 19.6 |
| 4 | 1,2 | Same as Plot 1 |  |  |  |  |  |  |
|  | 3,4 | 2 lb.LA, 1 lb.Xan., 2 qt.Ker.,1 lb.CP, 1/4 lb.Zs,1/2 lb.L. |  |  |  |  |  |  |
|  | 5-7 | 2 lb.LA,1 lb.Xan., 1 lb.ZS,2 lb. L. | 17 | 184 | 3,275 | 77.1 | 11.3 | 26.0 |
| 5 | 1-4a | 1 pt.Nic.,5 lb.WB, 1 qt.SO |  |  |  |  |  |  |
|  | 5-7 | 2/3 pt.Nic.,3.3 lb. WB, 1 qt.SO |  |  |  |  |  |  |
|  | 8 | 2/3 pt.Nic.,1/2 lb. WB, 2 qt.MO | 34 | 264 | 4,814 | 88.2 | 4.9 | 8.3 |
| 6 | 1-4a | Same as Plot 5 |  |  |  |  |  |  |
|  | 5-8 | 3-1/2 lb.MDM, 1 qt.MO, 4 oz. SF | 18 | 233 | 3,271 | 83.7 | 9.4 | 11.0 |
| 7 | 1-4a | Same as Plot 5 |  |  |  |  |  |  |
|  | 5 | 2/3 pt.Nic.,5 lb. X110, 1 qt. MO |  |  |  |  |  |  |
|  | 6-8 | Same except 2 qt.MO | 37 | 267 | 3,939 | 84.3 | 8.0 | 11.6 |
| 8 | 1-3 | 3 lb.DM (8%), 3 pt. SO, 1 oz.ZS |  |  |  |  |  |  |
|  | 4,4a[3] | 3 lb.FPNB,1 lb.WB, 2 qt. 371 oil |  |  |  |  |  |  |
|  | 5 | 2.3 lb.FPNB, 1 qt.MO |  |  |  |  |  |  |
|  | 6-8 | Same except 2 qt.MO | 36 | 158 | 3,251 | 83.1 | 8.1 | 12.0 |

Table 5. - continued

| Plot | Cover sprays | Materials per 100 gallons | Average per tree - June 24 |  | Seasonal data |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  | Apples per tree | Clean apples | Per 100 apples |  |
|  |  |  | Worms | Stings |  |  | Worms | Stings |
|  |  |  | (Number) | (Number) | (Number) | (Percent) | (Number) | (Number) |
| 9 | 1 | 1 pt.Nic.,5 lb. X110,1 qt.SO |  |  |  |  |  |  |
|  | 2 | 1 pt.Nic.,5 lb. X110,2 qt.MO |  |  |  |  |  |  |
|  | 3-4a | 1 pt.Nic.,8 lb. X110,2 qt.MO |  |  |  |  |  |  |
|  | 5-8 | Same as Plot 7 | 4 | 93 | 2,994 | 88.3 | 5.6 | 8.6 |
| 10 | 1 | 1/2 pt.Nic.,3-1/2 lb. X110,1 qt. SO,8 oz. CP,4 oz. ZS |  |  |  |  |  |  |
|  | 2-4a | 1/2 pt.Nic.,3-1/2-4 lb.X110, 2 qt. 371 oil, 8 oz.CP, 4 oz.ZS |  |  |  |  |  |  |
|  | 5 | 1/2 pt.Nic.,4 lb. X110, 1 qt. MO, 8 oz.CP., 4 oz.ZS |  |  |  |  |  |  |
|  | 6-8 | Same except 2 qt.MO | 16 | 66 | 3,240 | 89.8 | 3.9 | 7.8 |
| Least significant difference - 5% odds |  |  | 29 | 150 | 1,236 | 5.2 | 3.1 | 7.9 |

1/ Kerosene contained 2.5% oleic acid

2/ Oil contained 5% oleic acid

3/ Full cover spray replaced top-off

It is evident from the infestation differences on June 24 that the ovicidal efficiency of mineral oil was unusually important during May and June of this season for reasons already discussed. Plots 9 and 10 among the nicotine plots and Plots 1 and 3 among the arsenical plots received 1/2 percent mineral oil in at least 3 first-brood sprays. The ovicidal effect of xanthone on Plot 4 in reducing both worms and stings was also important. Plot 2, on which kerosene replaced the mineral oil in 2 cover sprays, had the poorest control in the first-brood period for the lead arsenate treatments. Injuries increased less on this plot after June 2 than on any of the other arsenical plots, however, as a result of the very smooth film type coverage of lead arsenate-bordeaux obtained by addition of the crude phosphatides.

Among the nicotine treatments the standard tank mix nicotine bentonite gave the poorest results against first-brood worms but later when the ovicidal efficiency of the other treatments diminished it gave better comparative results and equalled the best at harvest.

The most promising treatment which may be of immediate use to growers was the new tank mix made with Mississippi bentonite and mineral oil as applied to Plot 9. This completely avoided the objectionable harvest residues of bentonite characteristic of the standard tank mix treatments. All visible residues on Plots 6, 7, 8, 9, and 10 were easily removed at harvest by brushing.

Treatment 10, because of its lower cost (25 percent less than Plots 5 and 9) and excellent control, is also very promising but certain factors must be investigated before it can be safely used on a large scale. It was the only nicotine plot on which foliage injury occurred. Nearly half the leaves in the tops of the trees showed traces of oil injury and the fruit colored less satisfactorily than on the other nicotine plots. Fruit color on Plots 5, 6, and 7 was outstandingly superior to that on the lead arsenate plots and slightly superior to that on Plots 8 and 9. The white residues remaining on the foliage are believed to have been responsible by increasing light intensity inside the trees.

Very severe foliage injury occurred on the four lead arsenate plots. This first appeared on Plot 2, 24 hours after the second cover spray and on the other plots soon after the third cover. By harvest, Plot 4 had approximately 74 percent of its foliage injured, Plots 2 and 3 about 50 percent and Plot 1 had 35 to 40 percent. Defoliation ranged from 15 to 30 percent.

Treatments 6 and 7 gave poorer results than larvicidal efficiency tests and deposit data had led us to expect, while Treatment 10 gave better results. There is reason to believe that control factors other than larvicidal and ovicidal efficiency were responsible. Such factors might or might not function similarly in large-scale tests.

Weekly examinations were made of 25 random apples from the top and 25 from around the bottom of each tree throughout the season. These examinations showed that from June 3 to Aug. 5 there was no increase in the number of injuries on Plot 5, while a steady increase occurred on all other plots. The injuries on Plot 7 increased 65 percent during the same period.

In this experiment, nicotine treatments were under a substantial handicap. Our experience has indicated that nicotine bentonite spray programs which give control equal to that of lead arsenate in small plot tests give still better comparative results on acreages large enough to minimize the effect of moth migration. In this set-up, the control that was obtained by both the contact and poisoning effects of the nicotine sprays on the moth population was more or less distributed over the entire block and over some of the adjacent trees sprayed with lead arsenate by the grower, and was not reflected in the data from the plots in which they occurred. These treatments were further handicapped by drift from lead arsenate-bordeaux sprays, and by the unusually hard orchard well water which decreased the proportion of insoluble nicotine in mixtures of the standard tank mix to 75.4 percent from the normal 85 to 90 percent. The severely injured and light foliage on the lead arsenate-sprayed trees in contrast to the full crop of healthy leaves on most of the nicotine plots may have resulted in increased moth migration to the latter. As regards Plot 10, the possibility that the crude phosphatides might be repellent to ovipositing moths in small plot tests must be investigated.

In the 6 nicotine plots control of leafhoppers, leaf miners and aerial colonies of woolly aphis was excellent while moderate infestations of each developed in all the trees sprayed with lead arsenate.

## Field test of nicotine sulfate as a poison for the moths

In 1937, dissections of female moths at this laboratory showed that they must have water before they can develop more than a limited number of normal eggs. Subsequent feeding experiments showed that moths would feed readily upon several poisonous mixtures, one of which was nicotine sulfate in water. A very small quantity was required to cause paralysis or death. Similar results have recently been reported by a Russian investigator who used sodium fluoride in place of nicotine sulfate.

A preliminary test was arranged late in the season to determine if small amounts of a poison spray applied to the tree tops at dusk would effect any control. A 10 x 18 row block (6.6 acres) in the center of a large orchard was used for the test. Sprays were applied with a portable rig to opposite sides of the tops of each tree on 12 evenings between Aug. 21 and Sept. 9. Twenty minutes were required for each application, which was timed to be completed about 10 minutes after sunset, when moth activity normally began. Nicotine sulfate (40%) was used at the rate of 2/3 pint per 100 gallons. The spray was shot as a coarse stream so as to form large droplets, about 2/3 gallon per tree being used in each application.

On Aug. 28 and 29, and again at harvest, 90 trees within and on opposite sides of the block were examined (stratified samples of 200 apples being used) and the increase in infestation noted. The fruit which dropped between the two examinations was ignored.

The results follow:

| Variety | Treatment | Average number worms and stings per 100 apples | | Percent change |
|---|---|---|---|---|
| | | Aug. 28 | Sept. 11 | |
| Turley | Sprayed | 70.3 | 75.5 | + 7.4 |
| | Unsprayed | 101.1 | 112.3 | +11.1 |
| | | Aug. 29 | Sept. 18 | |
| Rome Beauty | Sprayed | 44.0 | 60.9 | +38.4 |
| | Unsprayed | 56.1 | 84.8 | +51.2 |
| Winesap | Sprayed | 94.8 | 124.6 | +31.4 |
| | Unsprayed | 127.8 | 171.1 | +33.9 |

The effect, if significant, was slight. Unfortunately the grower applied a nicotine bentonite spray to both treated and untreated areas when our preliminary counts revealed the intensity of the third-brood attack. This narrowed the expected differences. Furthermore, heavy early evening dews provided competing moisture, and the hatch of eggs deposited Aug. 21 and 22 was underway before the first examination could be made. The method will be investigated further, if possible, and earlier in the season.

## The development of large differences in the ability of local codling moth populations to enter sprayed apples

Large unaccountable differences in the intensity of the spray programs required to control the codling moth within local areas in the Middle West led to studies of different local codling moth populations. The following is the summary of a paper which will be published in the near future:

Laboratory and orchard tests with more than 14,000 newly hatched larvae from each of two similarly situated orchards in the Ohio and lower Wabash valleys show that differences between populations have apparently developed within the last 5 years in their ability to enter sprayed fruit. The orchards were sprayed alike prior to 1936. Larvae from one, which has since been sprayed heavily with lead arsenate, were able to enter fruit sprayed with lead arsenate, nicotine bentonite, cryolite, or xanthone, but not phenothiazine, in significantly greater numbers than larvae from the other orchard, which was not sprayed after 1936.

No differences could be found in the ability of the two strains to enter unsprayed fruit or in the resistance of their eggs to xanthone, micronized nicotine bentonite, mineral oil, or mineral oil-nicotine sprays.

Observations indicated that the strain least susceptible to lead arsenate used less time in attempting entrance and crawled shorter distances over sprayed fruit suggesting that the difference in socalled resistance was behavioristic rather than one of general vigor.

Apparent resistance of the one strain to lead arsenate was considerably greater than to nicotine so that the latter insecticide gave better results than lead arsenate in laboratory tests against the more "resistant" strain but poorer results than lead arsenate against the "weaker" strain.

The results suggest that increases in the proportion of resistant strains in a codling moth population can be retarded, if not prevented, by utilizing more supplementary measures and insecticides that kill more of the adults and eggs than lead arsenate.

They also show the need for a survey of the variation in apparent resistance that may exist among different orchard populations in localities where comparative tests of insecticides are being made.

## Distribution of Hibernating Larvae

During April, 21 trees in 4 orchards were given a very detailed examination to locate all hibernating larvae. All larger pieces of ground debris were examined, after which three 20-degree sectors were carefully gone over and the total ground population was estimated. These studies have been underway for 7 years, complete records now being available for 64 trees. Larvae which survived on the ground averaged 27 percent of the total population and ranged from 9 percent in 1938 to 65 percent in 1937.

The most important data for 1942, which are given below on a per tree basis, indicate that the average grower in this region could easily effect a very substantial reduction in his codling moth population during the dormant season by scraping, pruning and employing certain clean-up operations.

| | | Orchard | | | |
|---|---|---|---|---|---|
| Average per tree | Expressed as | Reed | Dixie | Teschner | McDonald |
| Total larvae (dead and alive) | number | 13.0 | 81.0 | 104.8 | 131.4 |
| Dead larvae on tree | percent | 12 | 22 | 13 | 22 |
| Dead larvae on ground | percent | 100 | 14 | 9 | 20 |
| Total living larvae | number | 10.7 | 64.0 | 92.8 | 102.8 |
| Living larvae on tree | percent | 100.0 | 81.2 | 55.8 | 70.4 |
| Living larvae on ground | percent | 0 | 18.8 | 44.2 | 29.6 |
| Distribution of living larvae on tree: | | | | | |
| At ground line | percent | 2.7 | 0 | 10.0 | 0.3 |
| Within 5 ft. from ground | percent | 74.7 | 39.7 | 80.1 | 56.4 |
| 5 to 10 ft. from ground | percent | 14.7 | 10.9 | 3.9 | 2.2 |
| Above 10 ft. from ground | percent | 8.0 | 49.4 | 6.1 | 41.2 |
| Under bark | percent | 93.3 | 52.6 | 94.5 | 59.7 |
| In splits, cavities, stubs | percent | 6.7 | 47.4 | 5.5 | 40.3 |
| Distribution of living larvae on ground: | | | | | |
| Within 5 ft. of trunk | percent | 0 | 55.6 | 87.8 | 64.5 |
| 5 to 20 ft. from trunk | percent | 0 | 44.4 | 12.2 | 35.5 |
| In mummies | percent | 0 | 0 | 41.5 | 23.7 |
| In leaves | percent | 0 | 0 | 0 | 3.9 |
| In stubble | percent | 0 | 0 | 0 | 19.7 |
| In weed stems | percent | 0 | 0 | 0 | 31.6 |
| In wood[1] | percent | 0 | 100.0 | 58.5 | 21.1 |

[1] Includes protruding roots

## BELTSVILLE, MARYLAND

E. H. Siegler, In Charge

### LABORATORY TOXICITY STUDIES

Insecticide tests were made under laboratory conditions by the apple plug method. Approximately 100 plugs were included in the test with each material and, unless otherwise indicated, the materials were used at the rate of 4 pounds per 100 gallons.

Tests of synthetic organic compounds.--The results of tests with organic compounds that gave less than 50 per cent wormy plugs are recorded in order of larval survivals in table 1, together with the data for lead arsenate and check experiments. The results indicate initial toxicity only, that is, the plugs were sprayed and infested the same day.

Table 1.--Results of laboratory spray tests with organic compounds against newly hatched codling moth larvae.

| Material | Apple plugs | |
|---|---|---|
| | Wormy | Stung |
| | (Percentage) | |
| Unsprayed check | 94 | 0 |
| Lead arsenate | 27 | 14 |
| Thiocoumarin | 0 | 0 |
| 4,6-dinitro-o-cresol propionate[1] | 0 | 9 |
| 4,6-dinitro-o-cresol acetate[1] | 0 | 11 |
| Dihydrophenazine | 0 | 45 |
| 4,6-dinitro-o-cresol[1] | 1 | 0 |
| p-nitroiodosobenzene acetate | 4 | 29 |
| Phenoxathiin | 8 | 15 |
| Dibenzothiophene | 8 | 31 |
| Xanthone | 9 | 36 |
| P-bromo-n-ethylbenzene-sulfonamide | 9 | 3 |
| 2,4-dinitrophenol propionate | 11 | 17 |
| 1-phenyl-4-o-tolyl-semicarbazide | 15 | 3 |
| 2-Methyl-4,6-dinitro anisole | 15 | 4 |
| 1-Phenyl-4-o-tolylsemicarbazide | 15 | 12 |
| 2-Octanone semicarbazone | 17 | 2 |
| 4 (4-nitrophenyl) morpholine | 20 | 0 |
| Cyclopentanone semicarbazone | 21 | 0 |
| P-bromo-benzene sulfonamide | 25 | 0 |
| 2,4-Dinitro anisole | 31 | 1 |
| 2-Heptanone semicarbazone | 32 | 0 |
| Acetone semicarbazone | 35 | 1 |
| 2-Furaldehyde semicarbazone | 35 | 21 |
| 1,3-Bis (p-tolyl)-triazine | 37 | 0 |
| 4-Methylcyclohexanone semicarbazone | 38 | 0 |
| 2-Methylcyclohexanone semicarbazone | 42 | 0 |
| Phenylsulfone | 43 | 0 |
| Beta-naphthonitrile | 48 | 1 |

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[1] Caused severe injury to apple skin.

More than 50 percent wormy plugs resulted from tests with other organic compounds. These are listed below:

P-Bromodiphenyl

P-Bromo-n-ethylbenzene-sulfonamide

Benzimidazole

1-Nitroso-2-naphthol

3,4-Methylenedioxycinnamic acid

2,3-Dihydroxyquinoxaline

Sulfur thiocyanate

P-Nitroiodobenzene

Piperonyloin

5-Methyl-5-phenolhydantoin

4'-Methyl-3,4-methylenedioxy-chalcone

P-Chloro-isonitrosoacetanilide

O-Veratraldehyde semicarbazone

P-Nitrosodimethylaniline[1]

5-(P-Chlorophenyl-5-methyl-hydantoin

5-Pentamethylenehydantoin

P-Nitrobromobenzene

P-Bromo-n-butylbenzene-sulfonamide

Phthalamide

P-bromo-n-isbutylbenzene-sulfonamide

2-Bromo-anthraquinone

6'-Propionoxy-coumarano-2',3':
3,2-(6-propionoxy-2,3-diphenyl)-coumarine

P-Bromo-n-propylbenzene-sulfonamide

Thiocarbanilide

Nitrated soybean meal

6'-hydroxy-coumarano-2',3':
3,2-(6-hydroxy-2,3-diphenyl)-coumarane

Nitrated wood - A -

5-Aminosalicylic acid hydrochloride

Nitrated wood -B

Oxamide

6-Acetyl phenothiazine

1,5-Diphenyl-2,4-pentadien-1-one

6'Acetoxy-coumarano

Alpha,gamma,diphenyl guanidine

Naphthalene + hydrated lime

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[1] Caused severe injury to periphery of apple plug.

Judged by laboratory tests or small-scale experiments outdoors, certain of the compounds that appeared most toxic to the insect would not be practical for codling moth control. For example, the vapor pressures of thiocoumarin and phenoxathiin are too high for residual effectiveness; 4,6 dinitro-o-cresol is toxic to the apple skin, as are also the acetate and propionate of this compound. The 4,6-dinitro-o-cresol acetate alone did not produce injury to Stayman foliage, but when combined with wettable sulfur and hydrated lime it caused very severe injury. Dihydrophenazine caused moderate injury and p-nitroiodoso-benzene acetate produced slight injury to Stayman foliage.

Inorganic insecticides.--With the exception of lead arsenate, used solely for comparative purposes, very little consideration was given to inorganic compounds. R. H. Carter of the Division of Insecticides Investigations, Bureau of Entomology and Plant Quarantine, prepared cryolite by a new method. The results with this material compared favorably with those with natural cryolite and synthetic cryolite.

## LARVAL FEEDING ATTRACTANTS

During the fall of 1941, samples of dried apple pomace were obtained from two commercial fruit by-products plants which dry apple pomace for purposes of storing and extracting pectin from it. Alcoholic extracts of these samples were combined with lead arsenate and tested.

In view of the excellent preliminary results, studies were conducted to determine the relation of total solids in the extracts to effectiveness in preventing larval survivals. The total solids used in the tests were at the rates of 50 mg/cc,100 mg/cc, and 200 mg/cc of the extracts combined with lead arsenate (4-100) and (2-100). The results do not indicate a definite correlation between total solids and effectiveness, although in several tests there was a tendency towards increased effectiveness with increase of total solids. There is an indication, however, that a somewhat better kill was obtained through the addition of the extracts to lead arsenate than with lead arsenate alone.

To further complete the study of extracts of apple pomace combined with lead arsenate, experiments were made to determine what, if any, influence the addition of the extracts have on arsenical spray deposits. Seven lots of 100 apple plugs each were sprayed by means of mechanically controlled spraying equipment. Each lot was then divided into two parts of 50 plugs each and analyzed for spray deposits. The data showed strong uniformity in arsenical loads between the lots. The use of the extracts increased the arsenical deposit in proportion to the total solids content.

Extracts of commercial concentrated apple pomace.--Several experiments were made with dilutions of a commercial concentrated apple pomace combined with lead arsenate. The results do not indicate that these extracts improved the effectiveness of lead arsenate.

Tests of ground dried apple pomace.--It was thought that possibly ground dried apple pomace combined with lead arsenate might be used advantageously as a larval feeding attractant. It was accordingly prepared for spraying by grinding to 60 mesh or finer and tested at 24 pounds per 100 gallons with 1 pound of lead arsenate. The results indicate that it does not have promise for this purpose.

Test of apple pectin.--Another constituent of the apple, pectin (4-100), was added to lead arsenate to determine whether its presence was desirable. The result of its addition showed an increase in larval survivals over lead arsenate alone of from 16 to 39 percent.

## EXPERIMENTS WITH THE THUNDER GOD VINE

Tests of alkaloidal products.--A study of the chemistry of the toxic principles of the Thunder God Vine, Tripterygium wilfordii, which is being investigated by Fred Acree of the Division of Insecticides Investigations, Bureau of Entomology and Plant Quarantine, has not been completed. However, certain toxic components have been isolated which are designated for convenience as crystalline alkaloid and noncrystalline alkaloid.

Dosages much lower than those ordinarily used in codling moth experimentation, (0.02-100), (0.04-100), etc., have been employed in laboratory tests using the apple plug method. In consideration of this fact, the results indicate that these alkaloidal products exhibit unusually great toxicity.

In a residual test, apples infested a week after spraying gave results essentially similar to those with apples infested the same day as sprayed. However, the work was done under laboratory conditions which would doubtless be much more favorable to the stability of the sprays than outdoor conditions.

Effect of storing on toxicity of roots of the Thunder God Vine.--In continuing the studies of the possible value of this plant for insecticidal purposes, information was needed on the effect storing of the roots would have on their toxic constituents. Tests were made comparing extracts obtained from roots harvested in 1940 and 1941. Unfortunately the dosages were not the same, but were near enough to indicate that the older roots had not deteriorated a great deal.

## NORNICOTINE

A few tests were made of the alkaloid nornicotine, of its sulfate, and of nornicotine bentonite, each material being used at a concentration of 0.05 percent nornicotine. The results show that this chemical is more effective as a sulfate than in the other forms employed, giving a mortality about the same as that with lead arsenate.

## TESTS OF EXTRACTS OF PLANTS BELIEVED TO POSSESS INSECTICIDAL PRINCIPLES

Certain extracts of the following plants exhibited the best insecticidal properties, 49 percent or less of the plugs being wormy: African fish poison, Barbasco, Celastrus scandens, Euphorbia gum, Artimesia nova, Jacapa seeds, and Cypress weed. Extracts of other plants tested, but which were less effective, included: Turkey mullen, Narcissus, Mortonia scabrella, Wisteria, and Cassia emarginata.

## STUDIES ON LARVAL OLFACTORY LURES

Laboratory studies, started last year, to find a substance that would stimulate larval feeding were continued. In planning further investigations it was realized that certain substances might be attractive to the larva only after it has come into physical contact with the material. For this purpose paper absorption blocks were used on a small field of observation and materials under investigation were either absorbed on the block of paper or pressed into a solid mass the same size as the paper blocks. Paper blocks moistened with water were used as controls.

Attraction of larvae to moisture.--Since the apple is largely composed of water, the part moisture plays in attracting the codling moth larva was considered early in the investigations. A total of 87 observations was made of larvae which had a choice between a humid and a dry area. Observations were made at intervals of 15 minutes at which time the areas were interchanged. In only 5 cases were more larvae noted in the dry area than in the humid. During the period of the tests, 781 larvae were observed in the dry, whereas 1659 were noted in the moist area. The mean difference in the larval attraction between the moist and the dry areas was 36 percent. The least significant difference (.05 level) equals 32 percent; (.01 level) equals 42 percent.

Attraction of larvae to foliage and fruit (Stayman).--In conducting tests to determine feeding responses of the larva to foliage and apple surfaces, the areas exposed were made equal and arranged so that the larvae had a choice. The larvae fed only on the fruit.

Attraction of larva to peel and flesh of fruit (Stayman).--In tests comparing the attractiveness of the peel and flesh of the fruit, 63 percent more larvae were attracted to the apple flesh than to the water control and 275 percent more larvae were attracted to the apple peel than to water. In tests with a slice of apple, the flesh being covered with wax and only the skin exposed, the number of larvae coming to it was 135 percent greater than the number coming to a control of dry paper. In tests in which larvae had a choice between two similar slices of apple, the difference was only 24 percent.

In other experiments the following observations have been made: (1) Apple juice, especially when diluted with 50 percent water, appeared to be more attractive than water, (2) Extracts of apple pomace failed to attract larvae, (3) Pieces of apple skin washed with acetone appeared more attractive than control pieces not washed, (4) Washings of apple skin with acetone contained attractive substances whereas washings with chloroform and carbon tetrachloride did not, (5) A concentrate from acetone extraction of apple peel was attractive to the larvae.

Miscellaneous tests.--Several chemicals were tested with 2 types of olfactometers. None of the materials proved attractive. Tobacco leaves and phenothiazine were decidedly repellent.

In connection with the work on the responses of newly hatched codling moth larvae to apple extracts, it was thought worth while to determine the oviposition reaction of the adult to these materials. As a first step, apples were placed in an oviposition cage every other day. During the six days apples were in the cage, a total of 3096 eggs was deposited while only 593 eggs were laid during the six day period when apples were not present.

## SMALL-SCALE TESTS TO DETERMINE EFFECT OF INSECTICIDES ALONE AND WITH FUNGICIDES ON FRUIT TREES

It is important to investigate promptly the safety to fruit trees of potential insecticides alone and combined with fungicides or other spray materials. This laboratory, therefore, tests as many as possible of those compounds that exhibit the highest toxicity to the codling moth larva. These tests, however, are necessarily on a reduced scale because of the small quantities of the spray compounds available. Under conditions of application in which a hand sprayer is employed, materials found injurious would doubtless also give damage if applied by means of power sprayers; materials reported as giving no injury may, however, cause damage if applied with orchard equipment, especially during periods favorable to spray injury.

The compounds are tested for the most part on apple trees and, for the purpose of getting additional information, a number of tests are conducted on peach trees. This work is done in cooperation with the Bureau of Plant Industry of the United States Department of Agriculture. Observations are usually taken daily for a week, then at weekly intervals for about a month, with a final check-up about two months after the spray application.

The effect on the foliage of Stayman apple and Elberta peach trees of compounds that resulted in less than 50 percent wormy plugs in laboratory tests is shown in table 2. The compounds were tested alone or in combination with other spray materials and, unless otherwise indicated, the materials were used at the following dosages per 100 gallons: test compound--4 pounds, wettable sulfur (w. s.) - 6 pounds, hydrated lime (h.y.) - 6 pounds, lime sulfur (l.s.) - 3 pounds, Bordeaux mixture (Bord.) - 4 pounds copper sulfate, 8 pounds lime. In some instances more than one test of a compound or combination was made. In such cases the number of tests showing similar results is indicated.

Table 2.--Results of spray tests with various compounds and combinations on foliage of Stayman apple trees and Elberta peach trees, Beltsville, Maryland, 1942.

| | Injury | |
|---|---|---|
| | Apple | Peach |
| Acetone semicarbazone | none, slight | none |
| " " +wettable sulfur +hydrated lime | none | none |
| " " + Bordeaux | none | |
| Beta-naphthonitrile | | none |
| " " + wettable sulfur + hydrated lime | | none |
| 1,3-Bis(p-tolyl)-triazine | none | |
| " +wettable sulfur +hydrated lime | none | |
| P-Bromo benzene sulfonamide | none(2) | none |
| " +wettable sulfur +hyd. lime | none | none |
| +Bordeaux | none | |
| Cyclopentanone semicarbazone | none | none |
| " " +wettable sulfur +hyd. lime | none | none |
| Dibenzothiophene | none(2) | none |
| " +wettable sulfur +hydrated lime | none | none |
| " +Bordeaux | none | |
| Dihydrophenazine | moderate | severe |
| " +wettable sulfur +hydrated lime | moderate | severe |
| " +Bordeaux | moderate | |
| 2,4 Dinitroanisole | none(2) | none |
| " +wettable sulfur +hydrated lime | very slight | none |
| " +Bordeaux | slight | |
| 4,6 Dinitro-o-cresol | very severe, defoliated | severe |
| " +lead arsenate | | moderate |
| " +wettable sulfur +hyd. lime | severe | severe |
| " +Bordeaux | moderate | |
| " (1-100) | slight | severe |
| " (1-100)+hyd. lime(8-100) | severe | severe |
| " (1-100)+hyd. lime(16-100) | | severe |
| " (1-100)+hyd. lime +wettable sulfur | | severe |
| " (1-100)+lime sulfur | severe | severe |
| " (.02-100)+lead arsenate(1-100) | moderate | |
| " (0.4-100)+talc(8-100) | severe | severe |
| " (0.4-100)+bentonite(8-100) | severe | severe |
| 4,6 Dinitro-o-cresol acetate | none(2) | severe |
| " +wettable sulfur +hyd. lime | very severe | severe |
| " +Bordeaux | none | |

Table 2 (Continued)

| | Injury | |
|---|---|---|
| | Apple | Peach |
| 2-Furaldehyde semicarbazone | none, slight* | none |
| " " +Bordeaux | none | |
| " " +wettable sulfur +hyd. lime | very severe | none |
| 2-Heptanone semicarbazone | none(2) | slight |
| " " +wettable sulfur +hyd.lime | none | slight |
| " " +Bordeaux | none | |
| 2-Methyl-4,6-dinitroanisole | none, moderate | severe |
| " +Bordeaux | slight | |
| " +wettable sulfur + hyd. lime. | severe | |
| p-Nitroiodosbenzene acetate | none, slight | slight |
| " +Bordeaux | none | |
| " +wettable sulfur +hyd. lime.. | slight | slight |
| 4(4-Nitrophenyl) morpholine | none(2) | none |
| " +wettable sulfur +hyd. lime.. | none | none |
| " +Bordeaux | none | |
| Phenoxathiin | none(2) | none |
| " +wettable sulfur +hydrated lime | none | none |
| " +Bordeaux | none | |
| 2-Octanone semicarbazone | none | none |
| " " +wettable sulfur +hyd.lime | none | none |
| Phenylsulfone | none(2) | none |
| " +wettable sulfur +hydrated lime | none | none |
| " +Bordeaux | none | |
| Thiocoumarin | none, very severe* | slight |
| " +wettable sulfur +hydrated lime | none | moderate |
| " +Bordeaux | none | |
| Xanthone | none(2) | none |
| " +wettable sulfur +hydrated lime | none | none |
| " +Bordeaux | none | |
| Check (unsprayed) | none(4) | none(5) |
| Lead arsenate | none(5) | severe(5) |
| Lead arsenate (1-100) | none | severe |
| Bordeaux | none(2),moderate | |

*Probably due to fire blight.

| | | |
|---|---|---|
| Lead arsenate + Bordeaux | none(3) | |
| Lead arsenate + wettable sulfur +hyd. lime | none(3) | (slight(2)<br>(moderate-<br>(severe(2) |
| Wettable sulfur + hydrated lime | none(3) | none(5) |
| Lime - sulfur | | severe |
| Lime - sulfur (3-100) | slight | |

## POUGHKEEPSIE, NEW YORK

P. J. Chapman and R. W. Dean, New York Agricultural Experiment Station, and D. W. Hamilton, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture.

These investigations were carried on jointly by the Bureau of Entomology and Plant Quarantine and the New York Agricultural Experiment Station at the Hudson Valley Fruit Investigations Laboratory, Poughkeepsie, N.Y.

### Seasonal Developments

Mortality of codling moth during the winter of 1941-42 was low, averaging 24.4, 9.3, and 6.6 percent in three orchards where mortality counts were made in the spring of 1942.

Codling moth emergence began earlier than average for this locality for the second consecutive season. Pupae were found as early as April 25, and adults were captured in bait traps on May 13. Larvae began entering the fruit May 29. High temperatures in early spring were followed by several days of lower temperatures, which slowed down codling moth development and split the emergence of spring-brood moths. While this prolonged the period of spring-brood moth activity, it apparently reduced the vitality of the moths and eggs so that first-brood injury was not generally so severe as that experienced in past seasons. Peak bait trap captures of spring-brood moths occurred May 23-29 and June 5-10. Weather conditions were very favorable for second-brood codling moth activity, and injury in several orchards became severe, especially where annihilation sprays were not applied for complete control of the first brood. The latter part of August and early September were unusually favorable for codling moth development so that activity was higher than normal during this period. Peak bait trap captures of first-brood moths occurred August 1-10, and 19-21. Spray protection was at a low ebb in most commercial orchards and also in the randomized plot insecticide tests during the period of August 19-30, and it was during this period that a high percentage of injury was caused by the codling moth. Winter carry-over is very high in certain orchards and will probably average higher than last season in most orchards. Severe winter temperatures during the month of December, ranging from -18 to -28, have probably increased the mortality of larvae now overwintering.

### Field Testing of Insecticides

#### (a) Control of Codling Moth by Annihilation Sprays During Early Season Activity.

Field tests of so-called "annihilation" or "blitz kreig" type spray schedules were continued for a third season. A semi-isolated orchard of approximately 172 mature apple trees was used for these tests. Principal varieties were Cortland and McIntosh. These trees, while headed back and open at the bottom, had hollow crowned tops which made it difficult to properly cover the tops with spray.

Previous to 1941 this orchard had at least 30 percent wormy fruit when the usual arsenical and nicotine spray program was used. In 1941 the crop was light, the orchard was left unsprayed, and the apples were heavily infested with codling moth. Five bait traps located in this orchard during 1942 captured 325 moths, of which 72 percent were spring-brood adults. While the initial codling moth infestation was only moderate, the infestation was heavier than that in the orchard receiving the "annihilation" spray treatment in 1941.

Spray applications were made with a motorized 35-gallon-per-minute pump using 2 single nozzle guns, equipped with 9/64 inch orifices. Pressure was maintained at 575 pounds at the pump. For the most part sprays were applied from the ground working under and around each tree. However, due to the hollow crowns, the tops were touched up after each spray application by driving the spray rig through each row and spraying the top branches from the rig. Between 20 and 22 gallons of spray were applied per tree at each application.

The spray schedule consisted of lead arsenate calyx and curculio sprays, lead arsenate with nicotine sulfate for 1st and 2nd covers, 14 percent nicotine bentonite and summer oil for the 3rd cover, and lead arsenate for the 4th cover. The lead arsenate used in the 4th cover was combined with varying amounts of copper sulfate and /or lime for the purpose of studying the value of weak bordeaux as an arsenical corrective. The amounts of materials used, dates of application, and infestation records are shown in table 1.

Table 1.--Spray Schedule, infestation records, and rainfall for first brood codling moth annihilation experiment, Poughkeepsie, N. Y. 1942

Dates of application and materials used per 100 gallons of spray

Calyx - May 11

| | |
|---|---|
| Lead arsenate | 3 lbs. |
| Hydrated-lime | 3 lbs. |
| Micronized spray sulfur | 5 lbs. |

1st cover - June 2-3

| | |
|---|---|
| Lead arsenate | 3 lbs. |
| Hydrated-lime | 3 lbs. |
| (1/2 of orchard) | 1 lb. |
| Nicotine sulfate | 1/2 pt. |
| Micronized spray sulfur | 4 lbs. |

3rd cover - June 24

| | |
|---|---|
| 14 percent nicotine-bentonite | 1-1/2 lbs. |
| 83% oil emulsion | 2-1/2 qts. |

Curculio - May 19

| | |
|---|---|
| Lead arsenate | 3 lbs. |
| Hydrated-lime | 3 lbs. |
| (1/2 of orchard) | 1 lb. |
| Micronized spray sulfur | 4 lbs. |

2nd cover - June 12-13

| | |
|---|---|
| Lead arsenate | 3 lbs. |
| Hydrated-lime | 3 lbs. |
| Nicotine sulfate | 1/2 pt. |

4th cover - July 3

| | |
|---|---|
| Lead arsenate | 3 lbs. |
| Bordeaux, concentration varied from lead alone, with lime 1/2/1-1/2/100 to 3/4/3/100. | 3 lbs. |

Infestation Records

| Variety | No. trees examined | Apples per tree | Percent apples clean | No. per 100 Apples: Worm holes | Stings | Harvest residues* Gr. per lb. fruit AS203 | Pb. |
|---|---|---|---|---|---|---|---|
| McIntosh | 5 | 1602 | 97.9 | 0.6 | 1.8 | 0.019 | 0.040 |
| Cortland | 10 | 1677 | 96.5 | 1.3 | 3.1 | .021 | .053 |

*Analysis by G. W. Pearce and A. W. Avens, N.Y. Agric. Expt. Sta.

Rainfall (inches)

| | |
|---|---|
| May 12 to May 19 | 1.12 |
| May 20 to June 3 | 2.10 |
| June 4 to June 13 | 0.95 |
| June 14 to June 24 | 1.57 |
| June 25 to July 3 | 0.41 |
| July 4 to Sept. 7 (McIntosh harvest) | 5.67 |
| Total for McIntosh | 11.82 |
| Sept. 8 to Sept. 16 (Cortland harvest) | 1.16 |
| Total for Cortland | 12.98 |

Investigations made during the past 3 years indicate that the "annihilation" type spray schedules properly timed and applied against the first brood are the most effective and economical method of controlling moderate to heavy infestations of the insect in this locality.

Analysis of residues on the fruit at harvest indicated that the tolerances were exceeded only in the case of loads on the Cortlands and that these barely exceeded the tolerance. The visible residues laid down by the weak bordeaux and lead arsenate at the time of the final cover spray were present in only moderate amounts on harvested fruit. Arsenical injury was not present on any of the trees sprayed with the varying combinations, and it was concluded that in most instances in practical application lime alone would prevent arsenical injury and would be less likely to build up lead and arsenical deposits that would exceed the tolerance at harvest.

## Experiments on Randomized Plots

Experiments with various materials and programs were conducted in two separate orchards.

### Tests in Fix Orchard, Hudson, N. Y.

This orchard, located on a steep hillside, consisted of a solid block of McIntosh, mature in size, poorly pruned, and in need of topping back. During the past three years, 35 to 65 percent of the fruit had been damaged. All spraying was done from the ground, with the equipment described in the discussion of the annihilation experiment. Coverage in the tops of the trees was light and spotted, but was the same for all plots. Schedules tested were those considered as having possibilities for practical control of codling moth in heavily infested orchards without creating objectionable harvest residues on the fruit. For this reason several of the schedules consisted of lead arsenate early in the season followed by other insecticides at later dates. Plots consisted of 2 trees each, replicated 4 times, except number 13 which consisted of 4 trees selected at random from the grower's spray block adjacent to the experimental block.

The spray schedules tested and the results obtained are shown in table 2. All plots received a calyx application on May 10 (3 lbs. lead arsenate, 1 lb. lime, 6 lbs. micronized spray sulfur) and a curculio application on May 25 (3 lbs. lead arsenate, 1 lb. lime, 3 lbs. micronized spray sulfur, 1 gal. lime sulfur), both of which were applied by the grower. Cover sprays 1 through 4 were timed with first brood larval activity, while numbers 5 and 6 were timed against second brood attack. The dates on which the various sprays were applied and the rainfall are shown below:

| Dates of Application | |
|---|---|
| Calyx | - May 10 |
| Curculio | - May 25 |
| 1st cover | - June 4-5 |
| 2nd cover | - June 17-18 |
| 3rd cover | - July 1 |
| 4th cover | - July 10 |
| 5th cover | - August 4 |
| 6th cover | - August 14-15 |

| Rainfall (inches) | |
|---|---|
| Calyx to curculio | - No Record |
| Curculio to 1st cover | - 1.10 |
| 1st cover to 2nd cover | - 1.54 |
| 2nd cover to 3rd cover | - 0.00 |
| 3rd cover to 4th cover | - 1.78 |
| 4th cover to 5th cover | - 3.33 |
| 5th cover to 6th cover | - 1.76 |
| 6th cover to harvest (Sept. 7) | - 1.73 |
| Total | 11.24 |

The results of these tests are shown in Table 2.

Table 2.--Codling moth spray experiments-McIntosh plots-Fix Orchard, Hudson, N.Y., 1942.

| Plot | Covers | Materials 1/ (Amounts per 100 gal.) | Apples per tree | Per-cent apples clean | Number per 100 apples: Worm Holes | Number per 100 apples: Stings | Harvest residues* 2/ Gr. per lb. fruit: $AS_2O_3$ | Harvest residues* 2/ Gr. per lb. fruit: Pb. |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | LA 3 lb., L 3 lb., S 4 lb. | | | | | | |
| | 2 | LA 2 lb., L 2 lb., NB 1 1/2 lb., S 4 lb. | | | | | | |
| | 3 | LA 2 lb., L 2 lb., NB 1 1/2 lb., SM 1/4 lb. | | | | | | |
| | 5-6 | NB 1 1/2 lb., oil 1/2% | 1681 | 86.7 | 8.4 | 9.4 | 0.020 | 0.051 |
| 2 | 1 | LA 3 lb., L 3 lb., S 4 lb., F 1 lb. | | | | | | |
| | 2 | LA 1 lb., cube 2 1/2 lb., oil 1/4%, F 1 lb. | | | | | | |
| | 3-6 | LA 3 lb., Bord. 1/2-1 1/2-100 | 1740 | 88.3 | 6.8 | 8.6 | 0.030 | 0.070 |
| 3 | 1,2 | LA 3 lb., L 3 lb., S 4 lb. | | | | | | |
| | 3-6 | LA 3 lb., Bord.1/2-1 1/2-100 | 2784 | 88.7 | 6.0 | 9.1 | 0.073 | 0.167 |
| 4 | 1 | LA 3 lb., L 3 lb., S 4 lb. | | | | | | |
| | 2 | LA 3 lb., L 3 lb., C 2 lb. | | | | | | |
| | 3,5,6 | NB 1 1/2 lb., oil 1/2% | | | | | | |
| | 4 | LA 3 lb.,Bord.1/2-1 1/2-100 | 2634 | 88.9 | 6.5 | 8.3 | 0.024 | 0.050 |
| 5 | 1 | LA 3 lb., L 3 lb., S 4 lb. | | | | | | |
| | 2 | LA 3 lb., L 2 lb., C 2 lb. | | | | | | |
| | 3-6 | NB 1 1/2 lb., oil 1/4% | 1941 | 84.6 | 10.8 | 9.6 | | |
| 6 | 1 | LA 3 lb., L 3 lb., S 4 lb. | | | | | | |
| | 2 | LA 3 lb., L 2 lb., C 2 lb. | | | | | | |
| | 3-6 | NB 1 1/2 lb., oil 1/2% | 2346 | 90.3 | 6.6 | 5.5 | | |
| 7 | 1,2 | LA 3 lb., L 3 lb., S 4 lb. | | | | | | |
| | 3-6 | Xan. 2 lb., Sp. 8 oz., Ker. 3 pt. | 1908 | 82.9 | 9.3 | 11.8 | | |
| 8 | 1,2 | LA 3 lb., L 3 lb., S 4 lb. | | | | | | |
| | 3-6 | Pheno. 2 lb. | 2153 | 91.6 | 5.2 | 4.7 | | |
| 9 | 1 | LA 3 lb., L 3 lb., S 4 lb. | | | | | | |
| | 2 | LA 2 lb., Xan. 1 lb., L-2 lb., S 4 lb. | | | | | | |
| | 3,4 | LA 2 lb., Xan. 1 lb., L 2 lb. | | | | | | |
| | 5,6 | Xan. 2 lb., Sp., 8 oz., Ker. 3 pt. | 2501 | 86.5 | 6.4 | 10.3 | 0.012 | 0.031 |

Table 2.--(Continued)

| Plot | Covers | Materials 1/ (Amounts per 100 gal.) | Apples per tree | Percent apples clean | Number per 100 apples | | Harvest residues* 2/ Gr. per lb. fruit | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Worm Holes | Stings | $AS_2O_3$ | Pb. |
| 10 | 1 | LA 3 lb., L 3 lb., S 4 lb. | | | | | | |
| | 2 | LA 2 lb., L 2 lb., C 2 lb. | | | | | | |
| | 3-6 | NS 1/2 pt., oil 1/2% | 2119 | 90.7 | 6.4 | 6.0 | | |
| 11 | 1,2 | LA 3 lb., L 3 lb., S 4 lb. | | | | | | |
| | 3-6 | C. pheno. 2 lb. | 2662 | 89.0 | 6.3 | 7.4 | | |
| 12 | 1 | LA 3 lb., L 3 lb., S 4 lb. F 1 lb. | | | | | | |
| | 2-6 | LA 1 lb., oil 1/4% | 1933 | 87.0 | 8.1 | 10.0 | 0.044 | 0.096 |
| 13 | | Grower's schedule, sprayed by grower (LA 3 lb). No of covers unknown, but S 4 lb. included in 2nd. cover. | 2005 | 44.5 | 103.3 | 21.2 | | |

1/ LA - lead arsenate; L-lime; S-micronized spray sulfur; NB-14% nicotine bentonite, factory processed; SM-powdered skim milk; oil-summer oil; cube-cube root (5% rotenone); F-Fermate; Bord.-Bordeaux; C-Coposil; Xan.-xanthone; Sp.-spreader; Ker.-kerosene; Pheno.-micronized phenothiazine; NS-nicotine sulfate; C.pheno.-factory conditioned phenothiazine.

2/ Analysis by G. W. Pearce and A. W. Avens, New York Agricultural Experiment Station.

Best control was obtained on plot 8 where micronized phenothiazine was used in the last 4 covers. However, visible deposits of phenothiazine were considered objectionable at harvest and coloring of the fruit was affected. Factory conditioned phenthiazine, plot 11 left less visible residue, although sufficient to be objectionable, and did not give quite as good control as plot 8.

The nicotine schedules used on plots 10 and 6 seemed to be the most practical for codling moth control in this locality of any of the schedules tested. No differences were apparent in the control obtained with 14 percent nicotine-bentonite or nicotine sulfate with summer oil. The finish to the fruit on plot 10 (nicotine sulfate) was slightly better than that on plot 6. Nicotine bentonite with summer oil can be safely substituted for lead arsenate in the codling moth sprays in this locality providing sulfur has not been used as a fungicide. Unfortunately, nicotine is ineffective against apple maggot. Plot 4 suggests a means of using nicotine in the spray schedule but including lead arsenate in the 4th cover for control of apple maggot during the period in which this insect is most active. Such a schedule has been found useful in orchards lightly infested with apple maggot, but would probably be ineffective in a heavily infested block.

Plot 2 consists of a combined lead arsenate, cube root, and summer oil schedule as used in western New York and reported on by S. W. Harman of the New York Experiment Station in 1941. Plot 12 is the same schedule without the cube root.

Plot 7 was xanthone with spreader and kerosene used according to manufacturer's suggestions and preceded by lead arsenate. When xanthone was used in combination with lead arsenate (for a combined codling moth and apple maggot schedule) in plot 9, control was better than obtained with xanthone alone.

## Tests in Fraleigh Orchard, Red Hook, N. Y.

Trees in this orchard were mature but smaller than those in the Fix orchard and poorly pruned. Plots consisted of single trees replicated 3 times. Material used in most schedules had not been tested at this laboratory before under field conditions, which was the main reason for using a small number of trees. The infestation in this orchard had been moderate--15 to 40 percent.

Spray schedules used and the infestation records are shown in table 3. All plots received a calyx application on May 10-11 of 3 pounds lead arsenate, 3 pounds lime, 4 pounds micronized spray sulfur, and 1/4 pound powdered skim milk, and on May 20 all plots except No. 1 received a curculio application composed of the same materials. The first four cover sprays were timed for control of first-brood larvae.

Table 3.--Codling moth spray experiments-McIntosh plots-Fraleigh Orchard, Red Hook, N. Y.

| Plot | Covers | Materials 1/ (Amounts per 100 gallons) | Apples per tree | Percent Clean | Percent Injured by spray | Number per 100 Apples Worm Holes | Number per 100 Apples Stings | Harvest residues* 2/ Gr. per lb. fruit $AS_2O_3$ | Harvest residues* 2/ Gr. per lb. fruit Pb. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | LS 2 gal. | 2050 | 83.7 | | 11.4 | 9.3 | | |
| 2 | 1 | LA 3 lb., L 3 lb.,<br>S 4lb. | | | | | | | |
| | 2 | LA 3 lb., L 2 lb.,<br>C 2 lb. | | | | | | | |
| | 3 | WSC. (LA 3 lb.), C 2 lb. | 3124 | 98.3 | 52.8 | 0.5 | 1.2 | 0.028 | 0.065 |
| 3 | 1-5 | NS 1/2 pt., B 1 lb.,<br>So. 1/2 lb. | 3773 | 96.5 | | 1.7 | 2.1 | | |
| 4 | 1,2 | LA 3 lb., L 3 lb. | | | | | | | |
| | 3-5 | NB 1 1/2 lb., Sp.802.<br>Ker. 3 pt. | 2761 | 97.2 | | 1.1 | 1.8 | 0.007 | 0.018 |
| 5 | 1,2 | LA 3 lb., L 3 lb. | | | | | | | |
| | 3-5 | Xan. 1 1/2 lb., Sp. 8oz.<br>Ker. 3 pt. | 3795 | 96.9 | 2.5 | 1.0 | 2.4 | | |

Table 3.--(Continued)

| Plot | Covers | Materials 1/ (Amounts per 100 gallons) | Apples per tree | Percent Clean | Percent Injured by spray | Number per 100 Apples Worm Holes | Number per 100 Apples Stings | Harvest residues* 2/ Gr. per lb. fruit $As_2O_3$ | Harvest residues* 2/ Gr. per lb. fruit Pb. |
|---|---|---|---|---|---|---|---|---|---|
| 6 | 1,2<br>3-5 | LA 3 lb., L 3 lb.<br>M.Xan. 1 1/2 lb., Sp. 8 oz. Ker. 3 pt. | 4311 | 96.8 | 2.8 | 1.3 | 2.3 | | |
| 7 | 1-5 | Castor bean extract 2 1/2 gal. | 3166 | 91.0 | 77.2 | 7.3 | 4.0 | | |
| 8 | 1-3<br>4,5 | LA 3 lb., L 3 lb.<br>LA 3 lb., Bord. 1/2-1 1/2-100 | 3285 | 99.1 | 7.3 | 0.3 | 0.6 | 0.040 | 0.097 |
| 9 | 1-3<br>4,5 | LA 1 1/2 lb., L 1 1/2 lb.<br>LA 1 1/2 lb., Bord. 1/2-1 1/2-100 | 3228 | 96.9 | | 1.0 | 1.6 | 0.026 | 0.061 |
| 10 | 1-3<br>4,5 | LA 3/4 lb., L 3/4 lb.<br>LA 3/4 lb., Bord. 1/2-1 1/2-100 | 3970 | 97.0 | | 0.5 | 3.2 | 0.014 | 0.030 |
| 11 | 1<br>2<br>3,4A<br>5A-7A | LA 3 lb., L 3 lb.<br>LA 3 lb., L 3 lb., F 1 lb.<br>D 21 oil 3 pt., blood albumen 2 oz., F 1 lb.<br>D 21 oil 3 pt., blood albumen 2 oz. | 3817 | 95.0 | | 3.3 | 2.9 | | |
| 12 | 1<br>2<br>3,4A<br>5A-7A | LA 3 lb., L 3 lb.<br>LA 3 lb., L 3 lb. F 1 lb.<br>M 20 oil 3 pt., blood albumen 2 oz., F 1 lb.<br>M 20 oil 3 pt., blood albumen 2 oz. | 3895 | 97.6 | | 1.2 | 1.7 | | |
| 13 | 1,2<br>3-4<br>5 | LA 3 lb., L 3 lb.<br>Pheno. 2 lb., Sp. 8oz., Ker. 3 pt.<br>Pheno. 2 lb., blood albumen 2oz., Ker. 4pt | 3779 | 98.2 | | 1.0 | 0.9 | | |
| 14 | 1-5 | Nicotine cuprocyanide-3/4 lb. | 3651 | 95.5 | 97.7 | 3.7 | 1.5 | | |
| 15 | 1-5 | Cryolite 3 lb. | 2060 | 95.1 | stem--62.7<br>side--20.9 | 3.3 | 2.4 | Fluorine 3/ | 0.021 |

1/ LA - lead arsenate; LS - lime sulfur; L - lime; WSC mod. dyn. - Washington State College modified dynamite using 3 lb. lead arsenate; C - Coposil; NS - nicotine sulfate; B - Wyoming bentonite; So. - sodium oleate; NB - 14% nicotine bentonite, factory processed; Sp. - spreader; Ker. - kerosene; Xan. - xanthone; M.xan. - micronized xanthone; Bord. - bordeaux; F - Fermate; Pheno. - micronized phenothiazine. Four pounds of sulfur was also included in the first cover on all plots except No. 1 and in covers 2, 3 and 4 on plots Nos. 3 to 10 and 13 to 15, inclusive.

2/ Analysis by G. W. Pearce and A. W. Avens, New York Agricultural Experiment Station.

3/ Analysis by Insecticide Division, U. S. Bureau of Entomology and Plant Quarantine.

Spray injury consisted of light russetting. Residue on the fruit at harvest was excessive, which explains the reason such programs are not used more extensively in this non-wash region. Reduction in the quantity of arsenical used per 100 gallons of spray resulted in slightly poorer control, plots 9 and 10, although a high percentage of the fruit remained free of codling moth.

Phenothiazine used with kerosene and spreader or blood albumen gave good control, plot 13. However, when the phenothiazine was mixed with the spreader, a large part of it solidified and collected at the strainer of the pump. Blood albumen was used for the spreader in the fifth cover and a smooth kerosene emulsion resulted. Coverage with the blood albumen-kerosene emulsion was very smooth and visible spray deposits did not accumulate.

Sulfur used with 3 pints of kerosene did not seem to cause any injury to the fruit or foliage when combined with phenothiazine, nicotine bentonite, or xanthone, plots 13, 4, 5, and 6.

Washington State College modified dynamite spray with lead arsenate as the insecticide, plot 2 gave good control, but caused excessive residues of lead and arsenic. Coposil used with this material for scab control caused severe russetting of the fruit.

Nicotine bentonite (14% nicotine) with kerosene and spreader, plot 4, and tank mixed nicotine sulfate, sodium oleate, and Wyoming bentonite, plot 3, gave fair control, but were not as effective as lead arsenate. Visible residues on plot 3 were excessive at harvest.

Xanthone, spreader, and kerosene, plot 5, gave fair control. Micronizing the xanthone, plot 6, did not increase the control.

Plots 11 and 12 demonstrate the effectiveness of ovicides applied at 7 day intervals for controlling moderate infestations of codling moth. The D-21 oil was much less effective as an ovicide than the M-20 oil. These oils were coded by P. J. Chapman of the New York Agricultural Experiment Station, and are a part of a series under study by the Experiment Station.

The nicotine cuprocyanide used in plot 14 was furnished by Roy Hansberry of Cornell University, and is one of the bimetal salts under investigation by Hansberry and Norton. Control obtained with this material was comparatively poor and russetting to the fruit was severe.

Control was poor with the castor bean extract used in plot 7, although the injury was significantly less than that in the unsprayed plot, No. 1. Certain lenticels on the fruit seemed enlarged and injured.

Plot 15, sprayed with Cryolite throughout the season, showed poorer control than the lead arsenate schedule, plot 8. Fruit from plot 15 showed severe cracking on the cheeks and in the cup around the stem, and was slightly smaller in size. Cryolite could possibly be used in a few cover sprays without injury and still maintain control. Residues of fluorine after applying 5 covers were only 0.021 grains per pound of fruit.

### (c) Residues of Phenothiazine with Film Type of Cover

Objections to the visible residues deposited in a "Blotchy" manner by the micronized and conditioned phenothiazine were overcome by making a tank emulsion using 2 quarts of kerosene, 2 ounces of blood albumen (actual), and 2 pounds of micronized phenothiazine per 100 gallons of spray. This spray when applied to the trees gave a film type of cover that left little visible residue and at the same time was compatible with wettable sulfur. Initial deposits of phenothiazine made with this schedule were not as heavy as those made with the micronized phenothiazine, table 4, and further investigations are planned for the study of spreaders and stickers to be used with phenothiazine.

Table 4.--Phenothiazine deposits resulting from one application on Baldwin apples--Red Hook, New York. 1/

| Schedule | Deposits before weathering | | | Deposits after weathering and a 2.03 inch rainfall 2/ | | |
|---|---|---|---|---|---|---|
| (Amounts per)<br>(100 gallons) | Grains per lb. | Micrograms per cm.$^2$ | Milligrams per apple | Grains per lb. | Micrograms per cm.$^2$ | Milligrams per apple |
| 2 lb. factory conditioned phenothiazene | 0.115 | 15 | 1.84 | 0.041 | 6 | 0.88 |
| 2 lb. micronized phenothiazine | .097 | 12 | 1.67 | .069 | 9 | 1.34 |
| 2 lb. micronized phenothiazine, tank mixed with blood albumen and kerosene | .075 | 9 | 1.20 | .029 | 4 | .68 |

1/ Analysis by Insecticide Division, U. S. Bureau of Entomology and Plant Quarantine.

2/ Deposits September 1, 1942.

## Effects of Heavily Infested Codling Moth Orchards on Adjacent Orchards

For a number of years a grower near Kinderhook, N. Y. has considered it necessary to apply extra sprays to the parts of his orchard adjacent to a poorly sprayed orchard that has a heavy codling moth infestation. By applying extra cover sprays to the parts of the orchard adjacent to the heavy infestation, codling moth injury in 1940 and 1941 averaged approximately 8 to 10 percent regardless of the position of the trees within the orchard.

In 1942 this grower attempted to conserve spray materials by applying only three cover sprays to the whole orchard during first brood larval activity. The orchard spray rows were 50 trees long and perpendicular to the edge of the heavily infested orchard, which afforded an excellent chance to check the effect of the heavy infestation on this planting. Infestation records were taken at harvest on small uniform Cortland trees at varying distances from the edge of the heavily infested orchard.

Trees within 63 feet of the heavy infestation averaged 59 injuries per 100 apples; those 93 to 153 feet from the infestation averaged 43 injuries; those 183 to 903 feet averaged 31 injuries; while those at least 1113 feet from the infestation averaged 17 injuries. These data indicate although trees at least as far away as 903 feet were affected by migrating first brood females, the heaviest infestation occurred in the first and second rows or within 63 feet of the source of infestation, and that a second distinct drop in the infestation occurred between the fifth and sixth rows, or about 175 feet from the source. Extra sprays should therefore be applied to at least 6 or 8 rows adjacent to such a source of infestation.

## Codling Moth Bait Trap Experiments

Five bait solutions were compared in single tree plots arranged in a Latin-square. Moth captures by each bait solution are shown in table 5. Sugar-base baits changed only once during the season, using sodium benzoate to retard their fermentation, were as effective as baits changed every 20 days and conserved materials. The Malto Dextrin 146 bait with yeast was less effective than the sugar baits and is more expensive. However, such a bait can be substituted for the sugar bait when sugar is unavailable. Approximately one third of the total moths captured by each bait were females.

Table 5.--Codling moth captures in bait traps, 1942

| Bait solution 1/ | Number of moths captured May 15-31 | June 1-30 | July 1-31 | Aug. 1-- Sept. 12 | Total |
|---|---|---|---|---|---|
| 1 2/ Sassafras (6 drops), sugar (12%) 3/ Changed at 20 day intervals | 345 | 201 | 79 | 358 | 983 |
| 2. Sassafras (6 drops), sugar (12%) 3/ 1/4 gram sodium benzoate added at time of only change (July 6 or 15) | 207 | 251 | 184 | 433 | 1075 |
| 3. Sassafras (6 drops), sugar (12%), 3/ 1/4 gram sodium benzoate added 10 days after only change (July 6 or 15) | 243 | 211 | 133 | 387 | 974 |
| 4. Sassafras (6 drops), Malto Dextrin 146 (20%), 4/ 1/4 cake yeast. Changed at 20 day intervals | 287 | 159 | 74 | 368 | 888 |

1/ 10 drops oil of sassafras (natural) was added to each quart of bait at the time it was put out or changed.
2/ Average of 2 series.
3/ No. 13 brown sugar, 1 pound per gallon.
4/ One quart per 2 1/2 gallons.

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Apple Maggot Investigations, Poughkeepsie, New York, 1942
U. S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine, Division of Fruit Insect Investigations*

R. W. Dean
January 11, 1943

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*The work reported herein is in cooperation with the New York Agricultural Experiment Station, Hudson Valley Fruit Investigations Laboratory, Poughkeepsie, N.Y.

## Seasonal Activities and General Importance in 1942

Injury caused by the apple maggot in sprayed orchards was considerably less in 1942 than in the preceeding three or four years. This may have been due, in part, to increased control efforts on the part of more growers, but the probable cause was the shorter period of heavy fly emergence. Fifteen cages on artificially infested soil near Poughkeepsie yielded a total of

3,936 flies, as compared with 6,578 flies from fourteen cages in 1941. Emergence started on June 16, reached a peak on July 13, and ended on Sept. 3. This period corresponds to the usual period of fly emergence but, in 1942, emergence following the peak declined abruptly, and new flies were not emerging in the orchard in significant numbers later than July 23. Two spray applications, one 10 to 14 days after emergence started, and the second shortly after the peak of emergence, were sufficient to give adequate control. Emergence in 1941 covered a similar period but apparently was much heavier than in 1942. According to the commonly held belief that fly emergence is favored by a season of abundant rainfall, the reverse should have been true. It seems probable that this idea is erroneous.

## Control Studies

Control tests were made in five orchards of varying size. In each case, the entire planting was treated. The experimental treatments began with the curculio (10 day) spray. This application, together with the first and second cover sprays, were the same in all orchards and consisted of wettable sulfur, 3 lb. of lead arsenate, and 3 lb. of hydrated lime per 100 gallons, with or without skim milk powder. Subsequent treatments and the results obtained are shown in the accompanying table.

All of the schedules tested gave satisfactory control of the apple maggot under 1942 conditions but the value of the newer materials in a season of prolonged fly emergence is not known. The present situation in regard to rotenone supplies precludes the use of this material for apple maggot control, in any event.

Despite the abundance of rainfall, spray residues exceeded the tolerance on varieties ripening about the time of McIntosh, when lead arsenate was used in the later sprays. This was probably due to the application of an extra first-brood codling moth cover spray. Ordinarily, four cover sprays are sufficient, the second and fourth corresponding to the two apple maggot applications. In 1942, the third and fifth cover sprays coincided with the maggot sprays. Visible residues left by the conditioned phenothiazine treatment and the lead arsenate-Bordeaux mixture application were objectionable, the latter, in particular, leaving the fruit splotched and irregularly colored.

## Apple Maggot Control Studies- 1942

| Orchard | Materials 1/ | Application date | Percent Infested Fruit | | | Residue 2/ | |
|---|---|---|---|---|---|---|---|
| | | | Variety | 1941 | 1942 | $AS_2O_3$ | Pb. |
| 1. | Lead arsenate 3 lb., lime 3 lb., skim milk powder 1/8 lb. | June 24 | Cortland<br>Early McIntosh | | 2.5<br>.8 | | |
| | Dust: cube powder(5 % rotenone)13 lb., white oil 4 lb., pyrophllite 83 lb. | July 8,17,28<br>Aug. 6,15 | McIntosh<br>Northern Spy | 20-30 3/ | .2<br>3.9 | 0.015 | 0.036 |
| 2. | Lead arsenate 3 lb., lime 3 lb., skim milk powder 1/8 lb. | June 24 | McIntosh | 50 3/ | 1.0 | .017 | .040 |
| | Conditioned phenothiazine 2 lb. | July 8,20 | Red Delicious | | 1.6 | | |
| 3. | Lead arsenate 2 lb., xanthone 1 lb., lime 2 lb. | June 24<br>July 20 | Red Delicious | 30.8 | 1.9 | .013 | .036 |
| | Xanthone 1 1/2 lb., spreader 8 oz., kerosene 3 pt. | July 8 | | | | | |
| 4. | Lead arsenate 3 lb., lime 3 lb., skim milk powder 1/8 lb. | June 25 | | | | | |
| | Blackleaf 155C 1 1/2 lb., summer oil 1/2 gallon. | July 8,9 | McIntosh | 6.1 | 2.8 | .034 | .082 |
| | Lead arsenate 3 lb. skim milk powder 1/4 lb., Bordeaux 3/4-3-100 | July 20-21 | | | | | |
| 5. | Lead arsenate 3 lb. skim milk powder 1/8 lb. | June 29 | Gravenstein<br>Wealthy | <br>90-100 3/ | 2.6<br>10.8 | | |
| | Lead arsenate 1/2 lb., cube powder(5% rotenone)2 1/2 lb., summer oil 1 qt. | July 10,22<br>Aug. 1,13-14 | McIntosh<br>Red Delicious | | 1.0<br>1.5 | .038<br>.031 | .097<br>.074 |

1/ Amounts per 100 gallons.

2/ Analysis by G. W. Pearce and A. W. Avens, Division of Chemistry, New York State Agricultural Experiment Station.

3/ Estimated.

## YAKIMA, WASHINGTON

E. J. Newcomer, In Charge

### SEASONAL CONDITIONS

The winter of 1941-42 was rather warm, the mean temperature for November to February inclusive being over 3 degrees above normal and the lowest official temperature being 2 degrees above zero. Temperatures in March, April and May were about normal, with a surplus of rain in May. June was 2 degrees below normal, and July to September were much warmer than usual, the average temperature for this period being 6 degrees above normal. During July and August there were 35 days of 90°F. or higher and 12 days of 100°F. or higher. Hot weather continuing into September resulted in a greater codling moth infestation and poorer color of apples than in 1941.

Bait records were made in the same orchards as in previous years, and were as follows:

| | Myles Orchard | | | LeVesconte Orchard | | | Russell Orchard | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Spring brood | First brood | Total | Spring brood | First brood | Total | Spring brood | First brood | Total |
| 1940 | | | 38163 | | | 16064 | | | -- |
| 1941 | 16949 | 11784 | 28733 | 6708 | 9432 | 16140 | 3152 | 3295 | 6447 |
| 1942 | 4914 | 15313 | 20227 | 2233 | 14969 | 17202 | 751 | 3441 | 4192 |

Spring-brood moths were fewer in 1942 on account of a light infestation in the fall of 1941, but there were more first-brood moths owing to the longer period of warm weather in the fall of 1942. The total number in two of the three orchards was less than in previous years.

### BIOLOGICAL STUDIES

Moth Emergence Records.-Emergence of moths from overwintering larvae began about three weeks later than in 1941, as the entire period from January to May was considerably cooler, and was first observed April 28. Owing to cool weather in May and June, there was no definite peak, but emergence continued until the middle of July. At this time moths of the first brood began to appear. The emergence of first-brood moths reached a peak about the middle of August, and decreased gradually into September.

Bait Records.-Moths began entering baits May 5, three weeks later than in 1941. Owing to a low overwintering population and adverse weather conditions the numbers of moths caught were erratic and much lower than in 1941. The largest number caught in an orchard in one night was 514 (in 5 baits) as compared with 1295 in 1941. First-brood moths began to enter the baits about July 18, and reached a peak about August 17 to 23. Very few moths were caught after the middle of September.

Rotary Net Records.-The power-driven rotary net was operated in the same location for the third season. This net circulates about 10 feet from the ground close to two apple trees at a speed sufficient to catch all moths flying in its way, but of course does not attract moths as do the baits. The net caught 2616 moths during the season, compared with 2566 per bait for nearby baits. This compares with 5471 and 5896 respectively, caught in 1941. In the three years of operation, the net caught about 12,500 moths as compared with about 13,700 moths per bait for nearby baits. The baits, which are assumed to be attractive, thus caught less than 10% more moths, on the average, than the net, which merely catches the moths that happen to fly in its way. During the warmer part of the season the baits catch comparatively more moths than earlier, probably being more attractive in warm weather. The baits are undoubtedly attractive to the moths, otherwise very few would be caught in them, but this comparative study indicates that they may be attractive only for short distances. It also indicates that baits may be safely used to show the activity and relative numbers of the moths.

Egg Deposition and Larval Entrances.-Because of unfavorable weather no eggs were found until May 19, three weeks after the first emergence of the moths and also about three weeks later than in 1941. The peak of deposition of first-brood eggs occurred June 12 to 17, and of second-brood eggs August 19 to 28. Some eggs were deposited in September. The largest number of eggs was found on fruit sprayed with phenothiazine as in previous years. The next largest number was found on fruit sprayed with nicotine bentonite, followed by xanthone, with the fewest on that sprayed with lead arsenate. Previously the order was phenothiazine, lead arsenate, xanthone, and nicotine bentonite. However, the nicotine bentonite used in 1942 gave a smoother coverage than in 1941, which may account for the difference in the case of that material.

The first larval entrances were made about May 28, more than two weeks later than in 1941. Second-brood larvae began entering fruit after the middle of July and continued in large numbers until the middle of September, resulting in a heavier infestation than in 1941.

Proportion of Transforming and Overwintering Larvae.-Observations made during the last five seasons show that some larvae leaving the fruit as early as the first week of July may be overwintering larvae, and that the proportion of transforming to overwintering larvae decreases gradually until early August, after which it decreases rapidly until by the first of September there are practically no transforming larvae leaving the apples.

## ORCHARD SPRAYING EXPERIMENTS

The spraying experiments were made in three orchards in 1942, using single tree plats replicated 8 times in each orchard. From each tree random samples of 250 apples were taken at harvest, including both picked and dropped fruit. The orchards used were: (A) Delicious, about 20 years old, having a medium crop averaging 15 boxes to the tree, and a light infestation at the beginning of the season; (B) Rome, about the same age, heavy crop averaging 20 boxes to the tree and a fairly heavy infestation. In orchard C, there were also two rows of Jonathans, of the same age, about the same size crop, and with a heavy infestation, which were used for tests of paste and powdered lead arsenate.

A calyx and six cover sprays were applied in orchards B and C on the following dates: Calyx, Apr. 30-May 6; First Brood, 1st cover, May 22-28; 2d cover, June 4-10; 3d cover, June 16-19; 4th cover July 2-7; Second Brood, 5th cover, July 27-31; 6th cover, Aug. 13-19. In orchard A, on account of the very light infestation, a calyx and only four cover sprays were applied, on the following dates: May 5, May 29-30, June 11-12, June 22-24, Aug. 3-5. Since hot weather continued into September, it would have been better if an additional cover spray had been applied in this orchard.

Deposit analyses were made by C. C. Cassil, Division of Insecticides Investigations, on all treatments of lead arsenate, phenothiazine, nicotine bentonite, and xanthone before and after each cover spray. An average of five trees per treatment were sampled in the Winesap and Jonathan varieties, only three trees per treatment in the Rome variety, because of the scarcity of fruit, and only a limited number in the Delicious variety since there was a poor crop in that orchard. The samples were taken by clipping 25 apples at random from top to bottom of a tree and allowing them to fall into a tared glass jar.

Each sample was prepared for chemical analysis by adding a measured quantity of stripping solvent to the jar, turning the jar end over end in a rotating machine for five minutes and then pouring off a portion of the solution for analysis. Six percent sodium hydroxide was used as the solvent for lead arsenate residues, 0.5 percent sodium hydroxide for nicotine, 95 percent ethanol for phenothiazine and toluene for the xanthone residues.

Arsenic was determined by a method entitled "Extension of the Rapid Volumetric Micro Method for Determining Arsenic" by Cassil, published in J. A. O. A. C. XXIV, No. 1, p. 196 (1941); nicotine by the colorimetric procedure developed by L. N. Markwood and described in J. A. O. A. C. XXII, No. 2, p. 427 (1939); phenothiazine by a modification of the colorimetric method described by Eddy and DeEds in the Journal of Food Research 1937, Vol. 2, No. 4, p. 305; and xanthone by a colorimetric procedure developed by Cassil and Hansen which will be published in the near future. The colorimetric solutions were read for color density in a photoelectric photometer.

All results were calculated as micrograms per square centimeter of apple surface. The average deposits of six cover sprays for the Jonathan, Winesap and Rome varieties are given for before and after spray application in Table 1. There were only four cover sprays applied to the Delicious variety, and the limited number of analyses (1sample per treatment at the 3rd and 4th covers) indicated that all sprays were being deposited as well as on the other varieties. Residues at harvest are also given in most instances.

Table 1.--Average residue deposits of six cover sprays for the 1942 season, expressed in micrograms per square centimeter. Yakima, Washington.

| Treatment [1] | Residue | Winesap | | | Rome | | | Jonathan | | | Delicious [3] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Before spray | After spray | Harvest [2] | Before spray | After spray | Harvest [2] | Before spray | After spray | Harvest | Harvest |
| 1 | $As_2O_3$ | 18.2 | 33.4 | 35.6 | 17.6 | 29.3 | 32.6 | 19.5 | 33.7 | 22.1 | 16.1 |
| 2 | $As_2O_3$ | | | | | | | 16.4 | 24.4 | 16.4 | 13.6 |
| 3 | Phenothiazine | 7.7 | 17.7 | 8.7 | 9.5 | 19.9 | 10.3 | | | | 2.7 |
| 4 [4] | $As_2O_3$ | 14.3 | 23.5 | 20.4 | 12.1 | 23.2 | 19.3 | | | | 10.1 |
| 5 | $As_2O_3$<br>Phenothiazine | | | | | | | | | | 6.7<br>0.9 |
| 5a | $As_2O_3$ | 9.7 | 16.4 | 14.7 | 8.6 | 15.0 | 15.9 | | | | |
| 5b | Phenothiazine | 3.7 | 10.5 | 4.6 | 4.3 | 10.8 | 4.6 | | | | |
| 6 | Phenothiazine | | | | 10.4 | 25.6 | 11.2 | | | | |
| 7 | Phenothiazine | 6.6 | 15.1 | 8.3 | 7.7 | 16.2 | 11.9 | | | | 2.5 |
| 8 | $As_2O_3$<br>Xanthone | 6.1 | 25.8 | 6.8<br>7.3 | 6.1 | 21.5 | 2.4 | | | | 1.6 |
| 9 | Nicotine | 3.1 | 6.3 | 3.4 | 3.3 | 7.3 | 3.3 | | | | 1.2 |
| 11 | $As_2O_3$ | | | | 9.1 | 14.6 | | | | | |

[1] See table 3 for details of treatments.

[2] Where the residues at harvest are greater than the average after-spray residues, this is the effect of a build-up deposit, e.g. the Winesap apples in treatment No. 1 had a peak cover of 50.2 mmg. $As_2O_3/cm^2$ after the sixth spray.

[3] Only four covers applied. Residue analyses based on 1 sample per treatment at the 3rd. and 4th covers.

[4] Treatment same as No. 3 for first four cover sprays. Residues given are average arsenic deposits for the last two covers.

It is of interest to note that with the development of a better sticker, it has been possible to apply about as much phenothiazine per unit area with a concentration of 1 lb. per 100 gals. in the spray mixture as had been applied previously with 2 lbs. per 100 gals. The mixture of 2 lbs. did apply more during the first two cover sprays, probably due to difference in skin texture but there was no significant difference in the last four cover sprays.

The analytical method for determining xanthone residues on apples, which was developed this past season, has aided immensely in the study to find out why xanthone has failed to give satisfactory control. Analyses of xanthone sprayed apples have shown as much as 80 percent loss of xanthone in a period of two weeks of hot weather. The last cover spray was applied on August 14, and at that time a series of analyses were started to study the rate of weathering of xanthone residues from the fruit. The daily maximum temperature in the orchard for the first 38 days of this study was 84.6°F ± 8.7°F. The average results from six trees are summarized in Table 2. The amount of lead arsenate lost over the same period expressed in mg. per apple was negligible.

Table 2.--Loss of xanthone residues from apples due to weathering.

| Date | mmg. xanthone per $cm^2$ | % loss | mg. xanthone per apple | % loss |
|---|---|---|---|---|
| 8/14 | 29.2 ± 2.2 | 0 | 1.95 | 0 |
| 8/15 | 27.9 ± 2.4 | 5 | 1.81 | 7 |
| 8/17 | 24.1 ± 2.3 | 18 | 1.61 | 17 |
| 8/22 | 16.2 ± 1.6 | 45 | 1.21 | 38 |
| 8/31 | 13.0 ± 1.6 | 56 | 0.97 | 50 |
| 9/21 | 8.8 ± 2.0 | 70 | 0.86 | 56 |
| 10/12 | 7.3 ± 0 | 75 | 0.69 | 65 |

The results of the field spraying experiments are given in table 3.

Table 3.--Comparative efficiency of insecticides used in field spraying experiments. Yakima, Washington, 1942.

| No. | Treatment (Quantities per 100 gal.)[1] | Orchard A (Delicious) % wormy | Orchard A (Delicious) % injured | Orchard B (Rome) % wormy | Orchard B (Rome) % injured | Orchard C (Winesap) % wormy | Orchard C (Winesap) % injured | Orchard C (Jonathan) % wormy | Orchard C (Jonathan) % injured |
|---|---|---|---|---|---|---|---|---|---|
| 1. | Lead ars.(powder), 3 lbs.; spreader 1/6 lb.; mineral oil (emulsible), 1 qt. | 9.3 | 29.0 | 8.4 | 22.4 | 5.3 | 20.4 | -- | -- |
| 2. | Lead ars.(paste, 50% L.A.), 6 lbs.; tar soap, 1/5 lb. | 13.7 | 39.1 | -- | -- | -- | -- | 39.2 | 55. |
| 3. | Phenothiazine, 1 lb.; stove oil-casein emuls. 1 qt.[2] | 18.4 | 25.8 | 7.0 | 9.3 | 4.7 | 7.8 | -- | -- |
| 4. | Phenothiazine as in 3, 1st brood; lead ars. as in 1, 2nd. brood. | 16.1 | 29.3 | 11.0 | 19.4 | 6.3 | 17.1 | -- | -- |
| 5. | Phenothiazine, 1/2 lb.; lead ars. 1 1/2 lb.; stove oil, 1 qt.; spreader, 1/6 lb. | 21.0 | 35.6 | 15.5 | 23.7 | 7.7 | 18.6 | -- | -- |
| 6. | Phenothiazine, 2 lbs.; stove oil, 1 qt.; soap, 1 1/2 lbs. | -- | -- | 5.7 | 6.9 | -- | -- | -- | -- |
| 7. | Phenothiazine (conditioned), 1 lb.; stove oil-casein emulsion, 1 qt.[2] | 32.2 | 39.8 | 12.7 | 15.3 | 5.2 | 7.8 | -- | -- |
| 8. | Lead ars. as in 1, 1st and 2nd covers; xanthone 2 lbs.; stove oil-casein emulsion, 1 qt.[2] remaining sprays | 16.2 | 30.9 | 23.2 | 36.7 | 22.9 | 36.8 | -- | -- |
| 9. | Nicotine-bentonite (dry mix, micronized), 3 lbs.; summer oil emulsion, 1 qt.; aluminum sulfate, 1 oz. | 16.2 | 24.7 | 15.8 | 22.4 | 14.7 | 22.5 | -- | -- |
| 10. | Lead ars.(powder), 3 lbs.; summer oil emulsion 1 qt.; spreader, 1/6 lb. | -- | -- | 10.1 | 28.9 | -- | -- | 24.8 | 40.0 |
| 11. | Same as 10, except lead ars. 1 1/2 lbs. | -- | -- | 33.3 | 53.9 | -- | -- | -- | -- |
|  | Differences required for significance (19 to 1) | -- | -- | 9.4 | 15.0 | -- | -- | 6.8 | 6.5 |

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[1] Calyx spray lead arsenate in all tests.

[2] Stove oil 3 gals., water 1 gal., casein 6 oz. ammonium hydroxide 56cc., cresol (preservative) 40 cc.

The paste lead arsenate (2), used as recommended by the manufacturer, resulted in more worms in the Delicious than the dry lead arsenate (1) but the difference was not significant. However, the difference in percentage of injured fruit was significant. In the Jonathans the differences in percentage injured were both significant. Evidently tar soap used with the paste lead is not as good as oil emulsion and sticker with dry lead, and this is further shown in table 1 by the lower deposits obtained from treatment 2 than from treatment 1.

In the single test of lead arsenate at half strength (11), as suggested by the Committee on the Insecticide Supply Situation deposits were about half as great and there was a significant difference in control.

The micronized phenothiazine at 1 lb. with stove oil-casein emulsion (3) gave results as good as powdered lead arsenate in two of the orchards, and was poorer only in the Delicious orchard, where insufficient spraying was done. The number of stings was much less. The same treatment with lead arsenate substituted for phenthiazine in the second-brood sprays (4) was as good as lead arsenate in all three orchards, indicating that the lead arsenate held the worms better late in the season than the phenothiazine. When half quantities of each of the two materials were combined (5) results were again significantly poorer in the Delicious orchard but not in the other two. Phenothiazine at 2 lbs. with stove oil and soap (6), used in the Rome orchard, was no better than the 1 lb. dosage with the emulsion (3) and the deposits were about the same. A conditioned phenothiazine containing an antioxidant was tried (7), and it appeared to be somewhat poorer than the regular material, probably due to its consisting of only 85% phenothiazine. Deposits in most cases were lower.

Xanthone used at 2 lbs. with the stove oil-casein emulsion after the 2nd cover spray (8), was significantly poorer than lead arsenate (1), except in the Delicious orchard. This may be due to the rapid weathering indicated in table 2.

A nicotine bentonite, in which the ingredients had been thoroughly mixed and then micronized, was used at 3 lbs. with an oil emulsion (9). It was significantly poorer than lead arsenate (1) in the Winesap orchard and just on the borderline in the other two. Nevertheless, these results are as good as those obtained in 1941 with 6 lbs. of the non-micronized nicotine bentonite.

In orchard C, 400 apples each in plats 1 (lead arsenate), 3 (phenothiazine), 4 (phenothiazine followed by lead arsenate), 5 (phenothiazine and lead arsenate mixed), 7 (conditioned phenothiazine), 8 (xanthone), and 9 (nicotine bentonite), were tagged early in July and a weekly record of the infestation was made until September 15 (Fig. 1). In general the data agreed with those taken from the harvested fruit. Plats 1, 3, 4 and 5 stayed well bunched as regards number of worms, and 7, 8 and 9 became considerably wormier, the increase apparently not being much hindered by the sixth cover spray. In total number of injuries, the phenothiazine stayed below the others.

The comparative degree of color of the apples in some of the plats was determined in the Delicious and Winesap orchards and is shown below:

| Plat | Treatment | % extra fancy Delicious | Winesap | Av. |
|---|---|---|---|---|
| 1 | Lead arsenate | 21 | 78 | 50 |
| 3 | Phenothiazine | 13 | 50 | 32 |
| 4 | Phenothiazine, 1st brood; lead ars., 2nd brood | 16 | 56 | 36 |
| 5 | Lead arsenate and phenothiazine mixed | 21 | 58 | 40 |
| 7 | Phenothiazine (conditioned) | 16 | 42 | 29 |

The phenothiazine, as in previous years, definitely reduced the color of the fruit, and it did not make very much difference how it was used. Only 21% of the Delicious sprayed with lead arsenate had extra fancy color, as the season was unfavorable for coloring this variety. In 1941, a favorable season, 82% had extra fancy coloring.

The average number of apples per box occurring in the various treatments is given in table 4. As in previous years, the phenothiazine appears to have had little effect on the size of Delicious or Romes, but to have definitely reduced the size of Winesaps. No other effects of the spray materials on the trees were noted.

Table 4.--Size of apples in plats receiving different treatments. Yakima, Washington, 1942.

| Plat | Treatment[1/] | Size (Av. No. apples per box) Delicious | Rome | Winesap | Jonathan |
|---|---|---|---|---|---|
| 1. | Lead arsenate (powdered) 3 lbs. | 85 | 85 | 155 | 148 |
| 2. | Lead arsenate (paste) 6 lbs. | 85 | -- | -- | 151 |
| 3. | Phenothiazine 1 lb.,casein-stove oil emulsion | 95 | 94 | 192 | --- |
| 4. | Same as 3, 1st brood; same as 1, 2d brood | 89 | 93 | 176 | --- |
| 5. | Phenothiazine 1/2 lb., lead ars. 1-1/2 lb. | 90 | 91 | 190 | --- |
| 6. | Phenothiazine 2 lbs., soap, stove oil | -- | 94 | --- | --- |
| 7. | Phenothiazine (conditioned) 1 lb. casein-stove oil emulsion | 81 | 87 | 184 | --- |
| 8. | Xanthone 2 lbs., casein-stove oil emuls. | 93 | 80 | 168 | --- |
| 9. | Nicotine bentonite (micronized) 3 lbs., oil emulsion | 82 | 78 | 177 | --- |

[1/] For detailed treatment, see Table 3.

## EXPERIMENTS AGAINST ADULT MOTHS

Some tests were made at Yakima along the lines suggested last year by the Dominion Division of Entomology Laboratory at Vernon, B. C., using sodium dinitrocresolate, made by adding 4-6 dinitro-o-cresol to a hot water solution of sodium carbonate. In preliminary laboratory tests in which moths were allowed to feed on cloths or wicks saturated with the test materials, the longevity of the moths was not significantly reduced by the dinitrocresolate, although it was by nicotine sulfate, as in shown below:

| | Av. length of life of moths, 3 tests |
|---|---|
| Water . . . . . . . . . . . . . . . . . . . . . . . . . | 5.4 days |
| 4-6 dinitro-o-cresol 3 oz., sod. carbonate 6 oz., to 100 gals. . . . . . . . . . | 4.9 days |
| Do., plus 5% molasses . . . . . . . . . . . . . . . . . | 5.8 days |
| Nicotine sulfate 1% . . . . . . . . . . . . . . . . . . | 1.6 days |

(The 4-6 dinitro-o-cresol was formerly known as 3-5 dinitro-o-cresol)

Sodium dinitrocresolate was compared with lead arsenate in orchard experiments made by confining moths in cages on limbs previously sprayed with the test materials. Two series of tests were made, using a total of 90 moths for each material. No reduction in the longevity of the moths occurred, but there was a reduction in the number of eggs laid and in the percentage of eggs that hatched. Mortality of the eggs was greater than normal in the lead arsenate check owing to unfavorable weather. No foliage injury was apparent. The results follow:

| Quantities per 100 gallons. | Total eggs laid by 90 moths | % eggs hatched |
|---|---|---|
| Lead ars. 3 lbs., oil emuls. 1 qt., spreader 1/6 lb. | 808 | 62 |
| 4-6 dinitro-o-cresol 3 oz., sod. carbonate 6 oz. | 530 | 34 |
| 4-6 dinitro-o-cresol 6 oz., sod. carbonate 12 oz. | 331 | 42 |
| 4-6 dinitro-o-cresol 3 oz., sod. carbonate 6 oz., glycerine 2 qts. | 640 | 32 |

## USE OF SPRAYS TO KILL HIBERNATING CODLING MOTH LARVAE ON TRUNKS

A large number of laboratory tests have been made with various dinitro compounds, nicotine compounds, dichloroethyl ether and other materials, to determine if a satisfactory spray for killing hibernating worms on the trees could be developed. Considerable attention has also been given to penetrants, since the material must penetrate the cocoons to be effective. A note in the Journal of Economic Entomology, Vol. 35, p. 450, June 1942, entitled "Sprays to Kill Overwintering Codling Moth Larvae", gives results of some of these tests.

In 1942 a large-scale orchard test was made, using 4-6 dinitro-o-cresol and although it turned out that this trunk spray, as used, killed only about 60% of the hibernating worms (the dilution used being less effective in the orchard than in the laboratory), the following results were obtained:

| Treatment | Eggs per 100 leaves June 4 | Injuries per 100 apples June 18 | Moth catch 2 traps per plat | Harvest count 200 trees per plat % wormy |
|---|---|---|---|---|
| Check | 49 | 31 | 6,235 | 18 |
| DNOC sprayed plat | 3 | 8.7 | 3,298 | 8 |
| Scraped and banded plat | 13 | 8 | 4,256 | 11 |

In the above test, all three blocks, including the check, were given the usual summer sprays for the codling moth by the owner. More extensive work along this line is planned for 1943.

## ORCHARD SANITATION

In a test of hoeing about the bases of infested apple trees, the ground under the north, south, east and west halves of 4 trees each was thoroughly hoed on May 12, the opposite halves being left as checks. The experiment was discontinued July 9, at which time only 7 moths had emerged from the hoed areas and no larvae or pupae were found in the soil; while 43 moths had emerged from the check areas and 12 larvae and 5 pupae were found in the soil. This indicates a reduction of about 88%.